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TOPOGRAPHIC AND GEOLOGIC SURVEY OF PENNSYLVANIA.

REPORT No. 1.

GEOLOGY OF THE OIL AND GAS FIELDS IN SEWICKLEY QUADRANGLE

By M. J. MUNN.

SURVEYED IN CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY

HARRISBURG:
C. E. AUGHINBAUGH, PRINTER TO THE STATE OF PENNSYLVANIA
1910.

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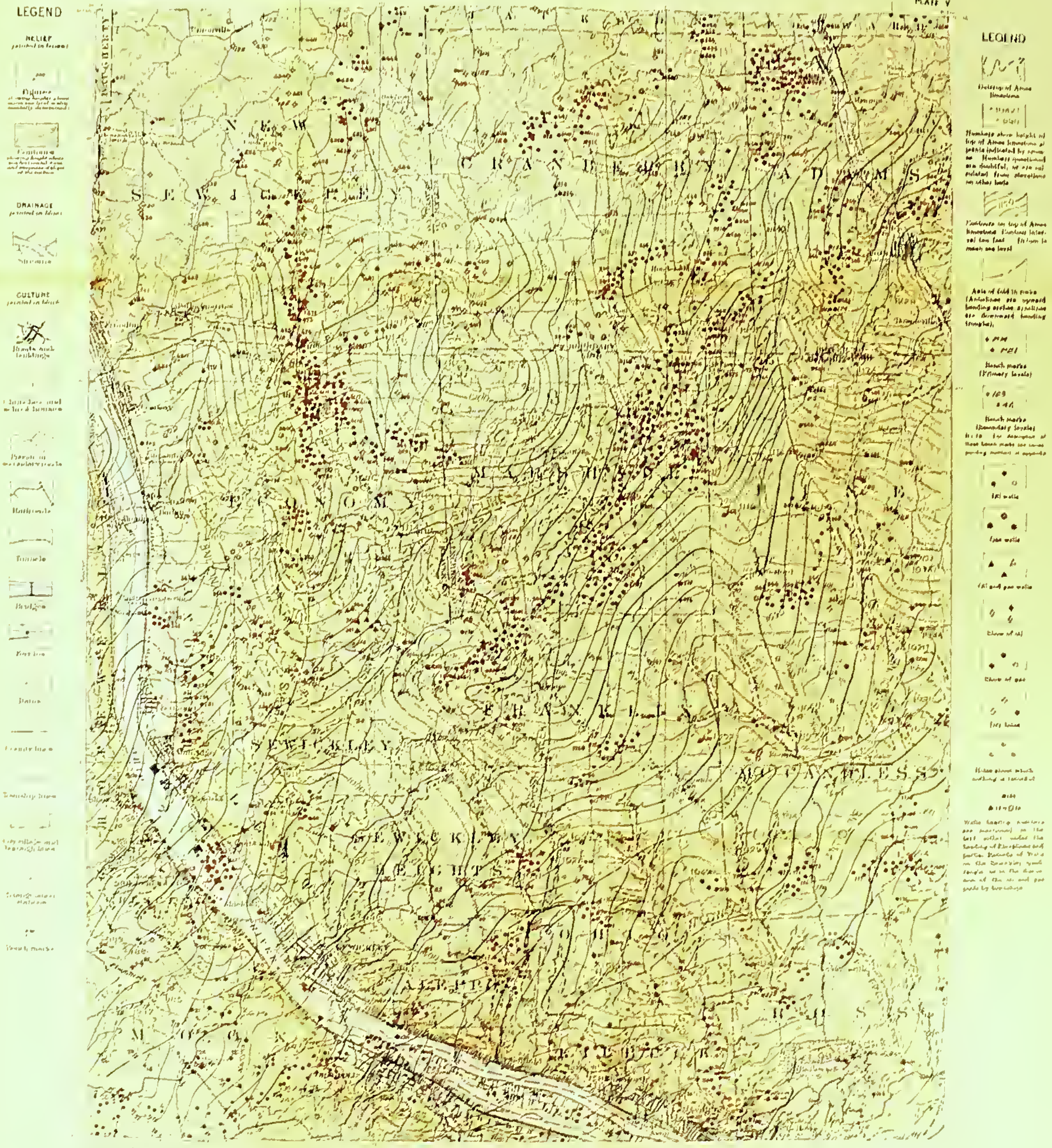

MAP OF SEWICKLEY QUADRANGLE PA., SHOWING OIL POOLS,
GAS POOLS, BENCH MARKS, AND STRUCTURE
CONTOURS ON TOP OF AMES LIMESTONE

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PENNSYLVANIA

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LETTER OF TRANSMITTAL.

Hon. George W. McNees, Chairman, and Members of the Topographic and Geological Survey Commission:

Gentlemen: It gives me great pleasure to submit herewith the manuscript and illustrations of a report on the Geology of the Oil and Gas fields in the Sewickley Quadrangle, by Mr. M. J. Munn.

The manuscript of this report has been ready for some time, but publication has been unavoidably delayed. It was originally planned as part of the last report of this Commission, but was not ready when that volume went to press. After the passage of the last act, by the Legislature of 1909, it was planned to make this the first of the reports issued under the provisions of that law, but while it will bear that number, other reports will probably be issued ahead of the present volume.

This report is in many respects the most detailed and accurate yet written on any oil and gas region, and is of corresponding value, not only to the operators in the fields of the Sewickley quadrangle, but to oil and gas operators generally, and to geologists.

The reports of the Second Geological Survey on the oil and gas regions were works of great value both to geologists and operators, and the more one examines them, the more he appreciates them, and the painstaking work of the late John F. Carll and his associates. These old reports, however, do not have the information needed by the operator of to-day. This is due not to any failure of those writing the reports, but to the advance that has been made in our knowledge of oil and gas in all their aspects, and to the fact that we now have the necessary base maps on which to properly lay down the results of our detailed study of structures.

Nothing, perhaps, will show more fully the advance in all respects than an examination of the maps accompanying this report. Particularly we will note the exceedingly irregular lines of the crests of the anticlinal axes as there shown, and the relation of these axes as shown in the rocks exposed at the surface to the same axes as shown by well records and contoured on the Hundred Foot sand. That similar detailed studies of all the oil and gas fields of the State will more than repay the cost and painstaking labor required will be freely admitted.

Mr. Munn has in one of his chapters pointed out what he believes are inconsistencies in the generally accepted theory of the relation of structure to the accumulation in paying quantities of oil and gas, the "Anticlinal theory" as it is generally known

The early work of the Second Geological Survey gave us a vast amount of information regarding the location and records of wells, but there then seemed no key by which any relation between structure and paying deposits could be laid bare. In Vol. J, (1875) Henry E. Wrigley in speaking of the oil and gas region of West Virginia and Ohio states plainly they were "confined to two plainly marked belts of geological disturbances, (anticlinal);" in this, evidently, following the conclusions of the late Prof. E. B. Andrews, as published by him in 1861. *(a)*

This well established connection between structure and accumulation in paying quantities did not, however, seem to impress the geologists of the Second Survey, indeed in one of the reports *(b)* it was distinctly stated by Prof. Lesley that "The supposed connection of petroleum with anticlinal and synclinal axes, faults, crevices, cleavage planes, etc., is now a deservedly forgotten superstition. Geologists well acquainted with the oil regions never had the slightest faith in it, and it maintained its standing in the popular fancy only by being fostered by self assuming experts who were not experienced geologists." It was not until 1883 that Dr. I. C. White, now State Geologist of West Virginia, after years of study of western Pennsylvania geology, discovered *de novo* the relation of the paying fields and pools of oil and gas to the various anticlinal axes which traverse the oil and gas regions. Dr. White not only made this discovery but at once proceeded to apply the deduced theory to practice in the development of oil and gas fields not only in Pennsylvania but elsewhere, and the marked success which has followed is the proof to the producer of the truth of the theory.

It has seemed, therefore, peculiarly appropriate that in view of the long association of Dr. White with the Second Geological Survey, and his especial studies in connection with the subject of this report, that he should be asked to give us a short introductory chapter to this volume, which he has most kindly done, and which it gives me especial pleasure to transmit herewith.

In his work Mr. Munn frequently notes the change in the character of the "sands." It has often seemed that not sufficient attention is given to this factor. In the reports of the Second Survey attention is frequently called to the sudden changes in sandstones, a very short distance carrying one from a massive sandstone to a shale at the same horizon. This was noted as *changes* in the sandstone. Recent observations of Dr. Percy E. Raymond, of the Carnegie Museum,

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(a) American Journal of Science, Series 2, Vol. XXXII, p. 85.
(b) Letter of Transmission, Vol. III, P. xvi. October 25, 1880.

Pittsburg, Pa., indicate the generally accepted understanding of these changes is not correct. He has found along the Ohio river, a few miles below Pittsburg, and elsewhere, distinct evidences that the changes are not variations in the structure of the sandstones, but are distinct *non conformities.* The sandstone was either never deposited in a continuous sheet, or was eroded before the shales occupying the same horizon were laid down, *(c)* and most probably the latter. Dr. Grabau has suggested the word *"disconformity"* for such conditions, which do not affect the conformity of the series as a whole.

Few, perhaps, fully appreciate the amount of erosion that was taking place during the time of the deposition of a sandstone. There was a distinct elevation of the land adjacent to the place of deposition, and there had been sufficient time for a thorough consolidation of older materials before the deposition of the sandstone began. A recent case of this was noted in the Homewood sandstone near Smith's Ferry, Pa., at the location of the "pictured rocks" there. The Homewood is there quite conglomeratic and among the pebbles were a number of well rounded coal pebbles, as much as two inches in diameter. The conclusion seems evident. They had their origin in some of the coal beds *below* the horizon of the Homewood, at least they antedated the time of the deposition of the Homewood at this point. After the deposition of the coal it had received sufficient cover to consolidate it, and it had been raised above drainage level, for it had been carried a sufficient distance by running water to well round it. All this indicates quite an erosion interval at the time of the deposition of the Homewood, and the existence of a pronounced *non conformity* is evident. Such occurrences as this, and the well developed *non conformity* at the base of the Pittsburg coal in the Carnegie quadrangle *(d)* only show the irregularities attending the deposition of the sandstones of the Carboniferous, and we should expect just as great irregularities attending the lower oil and gas bearing sands. We have no reason to expect the uniformity in character or extent over great areas without change, that has generally been expected by the operators and, at least tacitly, admitted by most oil geologists. As our knowledge grows irregularities attending the formation of sandstones become more pronounced.

The correct determination of the various formations exposed at the surface is of the greatest importance in any study of oil geology. In the case of the present report Mr. Munn has chosen the horizon of the Ames (Crinoidal) limestone as the most persistent and well defined, on which he has laid down the structure of the surface rocks. This is probably the best known horizon that could be chosen within the quadrangle, but there is a possibility that it may have been

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(c) Annals of the Carnegie Museum, Vol. V, p. 166.
(d) Report of the Commission, 1906-1908, p. 154.

wrongly identified in places. In the Report of the Commission for 1906-1908, page 159, Dr. Ashley, in speaking of the Ames within the Sewickley quadrangle, says, "Mr. Munn has noted one or two limestones between the Ames and the Bakerstown coal. These resemble the Ames so closely that he has had to depend on the association with the Ames of the yellow shale in which it lies and the red shale below to distinguish them. It is the highest limestone in the coal measures containing marine fossils." Where these two limestones are found the upper is undoubtedly the Elk Lick and its close resemblance to the Ames has been before noted. Dr. Raymond has found that it contains practically the same fossils as the Ames, and Dr. White has noted it at Morgantown, W. Va. It is undoubtedly more persistent than has been thought, and probably has often been mistaken for the Ames where there is but one limestone exposed. In the section taken by Mr. Munn one fouth mile east of Stoops Ferry he mentions the Ames Limestone as three feet in thickness, and 48 feet below a second limestone horizon which "closely resembles the Ames, but thinner," and in other sections he has noted two limestones with about the same interval. In view of the close resemblance of these two limestones, both in general appearance and in fossils, it may be the Ames has been wrongly identified as the upper of these two limstones, which fact may account for some of the irregularities in the distance between the Ames (as identified) and the Hundred Foot sand.

Most students of Pennsylvania geology will not agree with Mr. Munn's identification of the Galitzin with the Brush Creek coal. This identity does not seem settled, and inasmuch as the Brush Creek was named from this quadrangle, it might have been well to have retained the name in this report, pending final determination of identity with the Galitzin.

Very respectfully,

RICHARD R. HICE,
State Geologist.

December 31, 1909.

INTRODUCTION.

By I. C. White, *State Geologist of West Virginia.*

Such thorough and very detailed studies as those carried on by Mr. Munn over the area of the Sewickley quadrangle cannot fail to prove of great economic and scientific value. The true scientific spirit as exemplified by the author of this volume welcomes honest criticism, and full statements of opposing facts and theories since it is only thus that error can be eliminated, and final and lasting results obtained in the wide fields of practical geology covered by the problems connected with the origin, distribution and collection of petroleum and natural gas into pools of commercial value. To the older geologists like the late John F. Carll the occurrence of these pools or rich accumulations of oil and gas, appeared to be so arbitrary and irregular that they refused to credit any theory that would bring them under the domain of natural laws like those of gravity, hydrostatic pressure, etc.

The writer discovered the relation of geologic structure to accumulations of oil, gas, and water in the stratified rocks in 1883 without being aware that the same relations had previously been noted and published first by Dr. T. Sterry Hunt in 1859, later by Prof. E. B. Andrews, of Marietta, Ohio, in 1861, and by Prof. Herman Höfer, of Leoben, Austria, in 1876 So far as known, the conclusions of both Andrews and Höfer were made in complete ignorance of that of Dr. Hunt, the great Canadian geologist, just as the writer's discovery of what has been termed the "anticlinal theory" of oil and gas accumulation was based upon his own field studies without knowing that Hunt, Andrews, and Höfer had many years previously discerned and published practically the same conclusions. But none of these earlier and distinguished writers followed up his discoveries and put the structural theory to the test of practical application in the opening up of new oil and gas fields, so as to impress its usefulness upon the oil and gas operators, and hence the important truths they had announced remained buried in the pages of the scientific journals where they were first published. It fell to the lot of the writer not only to make the same discovery *de novo* which had been previously made by these three eminent geologists, but also to put the theory to such practical and successful tests in the field, that the structural or "anticlinal theory" has long ago been so firmly established in the minds of the oil and gas operators that no amount of reasoning could induce them to give up the idea that the accumulation of oil and gas into pools of commercial value is not in some way dependent upon geologic structure A few of them may say they do not believe in the "anticlinal theory" (whatever that may mean to them), but at the same time even these few are always governed by the rise and dip of the rocks in prosecuting the search for the hidden treasures of the hydro-carbon series, an unconscious tribute to the truths embodied in this structural theory, just as Mr. Munn in this report, although denying that geologic structure is the prime factor in oil and gas accumulation, yet nevertheless testifies to the contrary in the numerous suggestions and predictions he has given as to the direction and location where new oil and gas producing areas might be found.

The structural condition in a large portion of the Sewickley quadrangle are complicated by the occurrence of an immense thickness of coarse sandstone, porous at different levels, and doubtless holding much water originally imprisoned in this formation from the time when it was an old beach deposit, at the top of the Catskill series, not the base of the Carboniferous as Mr. Munn and Mr. Clapp regard it, since the top of the *Catskill* is found in the 60 feet of *red beds* which occur immediately above the Hundred Foot Sand. The immense volume of salt water in the Hundred Foot Sand under Pittsburg and Allegheny at the southeastern corner of the Sewickley quadrangle once formed the basis for a large salt manufacturing industry through a period of many years, and as the formation lies much lower below tide under Pittsburg than it does where it is petroliferous over the area of the Sewickley quadrangle, the salt manufacturers of Allegheny county were never troubled by the presence of petroleum in it like those at Tarentum, a few miles up the Allegheny river where the salt bearing stratum was a member of the Pottsville series, and where a shaft was once sunk to a depth of 400 feet for the pupose of trying to shut off the annoying petroleum which, appearing with salt water in the brines pumped from the "Salt Sand" of the early salt makers, gave an undesirable flavor to their product. The Hundred Foot Sand lies from 150 to 300 feet deeper below tide under Pittsburg than it does at the localities in other portions of Allegheny county where it holds petroleum in commercial quantity. The natural and most plausible explanation to account for this absence of petroleum at this lower level, and its presence along the crowns of the anticlinal arches a few miles northwest from Pittsburg as described by Mr. Munn would be on the theory of gravity. When a well flowing gas, oil and salt water empties its product into a tank, the three substances do not remain mixed, but they separate by gravity immediately, the gas escaping at the top of the tank, the salt water sinking to the bottom, and the oil rising and settling in a separate layer on top of the latter, so that both the petroleum and salt water can be drawn off through separate spigots. Why will this simple gravity process which instantly separates these three substances in the oil tank, not prove sufficient in spite of capilarity and other opposing agents, to separate them in nature's underground tanks by the same force (gravity) acting through countless years of time? When these underground reservoirs are but slightly inclined or nearly horizontal, no separation takes place except vertically and then we have the conditions found over large areas of Jackson, Mason, Putnam, Cabell, and Wayne counties of West Virginia for many miles south from the Ohio river where in drilling through the Oil Sand measures a little oil, a little gas, and some salt water are found, or in other words as the late Dr. Orton would say, "A little of everything and not much of anything."

When the quantity of salt water is very great, and the arch in the rocks is low and broad, as in the Sistersville field of Tyler county, W. Va., and adjoining regions of Monroe county, Ohio, the oil, gas, and water may remain commingled, since in all the area of that great field which at one time produced 20,000 barrels daily, only a single well produced gas alone, and this was on the Ohio side at the apex or very highest point of the Sisterville dome

This field which occurs in the Big Injun Oil Sand was condemned by the action of the first test well drilled, and was considered as salt water territory exclusively until two years later. In this first well, drilled on Polecat hollow, two miles northeast of Sistersville and known as the "Polecat well," a good showing of both oil and gas was discovered, but after pumping the same for several weeks through a two inch pipe no increase of oil to a commercial basis could be obtained Two years later, however, after the first producing well had been drilled, and it was learned that a three inch pipe was necessary to exhaust the pressure of salt water so that the oil could make its appearance, a pipe of this diameter was installed at the abandoned "Polecat" well, and after pumping salt water day and night for several weeks, the well began to flow oil, gas, and salt water, producing 500 barrels of oil daily, and about 1,500 of salt water, and proving one of the best wells in the field. As proof that this great field was subject to the same conditions over its entire area, the following incident is sufficient. When the field had reached the acme of its development and was producing 20,000 barrels of oil daily and probably 60 to 80 thousand barrels of salt water, a well was drilled near Middle Island creek, about 5 miles southeast of Sistersville near the southeastern edge of the field, where the "Big Injun" Sand reaches its lowest level, that flowed an immense quantity of salt water amounting at first to approximately 50,000 barrels daily with only an insignificant showing of oil. As soon as this immense salt water gusher was struck every well in the field, even ten miles distant, yielded much less salt water daily, thus proving that the relief of water pressure from this one outlet was propagated almost immediately over the entire field, instead of requiring many days or even months as might be inferred would be the case from some of Mr. Munn's observations on the rate of salt water movement in the rocks of the Sewickley quadrangle. This Big Injun Sand appears to be the lowest horizon at which any considerable quantity of salt water is found in the oil and gas rocks of West Virginia, except in Lewis county where a small quantity of water appears to occur over a small area in the "50 Foot" (lower portion of the Hundred Foot Sand of Pennsylvania), the Gordon. 4th, 5th, and Bayard sands being entirely free from perceptible quantities of water in every pool where oil or gas occurs. Since there is no salt water in these lowest oil sands the richest accumulations of oil often occupy the bottoms of the synclines, and this is especially illustrated by the deep Nineveh syncline in Wetzel county where, as shown by Mr. Hennen's contour map of the Pittsburg coal, that stratum descends to only 50 feet above sea level, reaching there the lowest level in the entire Appalachian basin. One cannot examine Mr. Hennen's structural map of Marshall, Wetzel and Tyler counties and note how the oil wells cluster along the bottoms, and slopes of the synclines, while the gas areas occupy the anticlines, and higher portions of the rock slopes, and not believe that this arrangement is due primarily to gravity, the dip of the strata having furnished the necessary relief.

One of the difficulties encountered by Mr. Munn is connected with his theory of the origin of petroleum, viz., that if of organic origin it must have originated in the shales below the oil sands, and passed by some method from the former to the latter, and, of course, if of inorganic origin, it must have come up from unknown depths through a great thickness of all manner of rocks. This last hypothesis we can dismiss at once, since it is not believed by any geologist whose opinions are entitled to serious weight, and never has been, and this "man of straw" has recently been given a knock-out blow by the investigations of Dr. C. Engler, a celebrated German chemist who has shown that the optical properties of petroleum practically demonstrate its organic origin.

Then, too, it is not necessary to assume that the petroleum originated in the shales, and has passed from them into the Sands, since the most of the evidence we have on the subject goes to show that the organic material out of which the petroleum was made, was buried in these old beach deposits where we now find the petroleum and natural gas, and hence the most of the pools of petroleum may have originated within the Sands where it is now stored, thus rendering such extensive movements of oil, gas and water as those assumed by Mr. Munn, unnecessary to be accounted for.

The northward rise of the strata from the Pittsburg region toward the shores of Lake Erie finally brings to the surface along the southern border of Erie county one of the best known and most widely distributed members of the Venango Oil Sand Group, viz., the *3rd Oil Sand* of the Titusville region. Being the only massive sandstone in the surface series of Erie county, it has long been quarried for building stone over a wide area, and hence with numerous natural outcrops is open to daylight inspection at thousands of localities. The early settlers of the district built many houses of this rock as a protection against Indian depredations. This *3rd Oil Sand,* although cropping at the surface, is still saturated with petroleum, and the stone houses built from its boulders more than 100 years ago, are streaked from top to bottom with dark bands of heavy oil which still moves by gravity slowly from the saturated pieces of this 3rd Oil Sand. In the commercial quarries at Le Boeff on the Erie Railway, the quarrymen (in 1878 when the writer visited the region in the preparation of his report Q4 on Crawford and Erie counties for the Second Geological Survey of Pennsylvania) were securing all the lubricating oil necessary for the use of a hoisting engine and other machinery used in the operation of an extensive quarry, from accumulations of the petroleum in fissures of the rock where it had oozed from the saturated Sand ("pay" streaks) and was sealed up by the underlying impermeable dark gray shales which did not appear to contain a trace of petroleum. This 3rd Oil Sand of Erie county was studied by the writer in detail at hundreds of localities in Erie county, during the Summer of 1878, and the conclusions then reached as to the origin of petroleum from organic remains imbedded in the Oil Sands are fully set forth in Volume Q4 of the Second Geological Survey of Pennsylvania series of Reports published in 1879, and the writer has not yet found any valid reasons for changing his convictions then formed from his inspection at first hands of a well known oil rock still saturated with petroleum and so well exposed for study.

The following classes of organic remains occur in this 3rd Oil Sand, one of the Catskill conglomerates, in large numbers: Molluscan remains of every description; fish remains; land plants, in the shape of trunks, and branches of trees, and multitudes of Marine plants, the latter being abundant only when the 3rd Oil Sand horizon passes into a shaly sandstone too fine in grain to hold petroleum in commercial quantity. Among all these classes or organisms whose bodies had been entombed in this old beach and shallow water deposit, it appeared to the writer there had been quite enough organic matter to account for the existence of the most prolific oil pool ever discovered, without the necessity of seeking such origin at lower levels either from underlying shales from which it may have subsequently migrated into the Sands, or from a supposed inorganic source, thousands of feet below, from which its ascent through several thousand feet of impermeable shales, clays, and other strata would have been a physical impossibility

Holding these views as to the origin of petroleum, and natural gas being a by-product, in its genesis from organic matter within the present reservoirs, it is unnecessary to discuss further the difficulties Mr. Munn has encountered in getting the petroleum and natural gas transferred from the underlying shales into the Sands above, especially when as it frequently happens, oil is now found in a sand immediately overlying one containing gas.

In the September-October, 1909, number of Economic Geology, pages 565-570, Mr. F. G. Clapp has so aptly answered many of Mr. Munn's objections to the anticlinal or structural theory of the accumulation of oil and gas pools that the writer considers that Mr. Clapp's views find an appropriate place in this Introduction, since Mr. Munn invited the widest discussion of his theories. Mr. Clapp's criticism reads as follows:

"The term "anticlinal theory" is an unfortunate one in some respects, as it gives a non-geologist the idea that the adherents to this theory believe the distribution of oil and gas pools to be dependent on anticlinal structure and on nothing else Such is not true, however. Personally, I have found it necessary scores of times, when questioned by well drillers or operators as to whether I believed in the "anticlinal theory," to qualify my affirmative replies by informing them that the theory holds as an important factor in the accumulation of oil and gas, even in pools in which no definite relation to geologic structure is apparent, and in regions where there are no definite anticlinal or synclinal axes. I have further found it necessary to qualify my replies by explaining that the structure of the rocks, and consequently the "anticlinal theory," is only *one* of the factors in the accumulation of oil and gas pools, and that a geologist, in order to locate a pool, even approximately, has to consider every other particle of evidence found in structure of the subsurface rocks, changes in intervals, texture of the "sands," character of the overlying beds, differences in pressure, relations to water in the rocks, shape of the surrounding pools, and character of the oil in the vicinity; and every factor must be given its due weight, before a recommendation can safely be made. After all other factors have been considered, it might seem as if the "anticlinal theory" had been lost sight of as unimportant; yet the fact remains that structure is the essential condition which finally determines the distribution and size of the pools when all other conditions are favorable.

"Mr. Munn's paper is an admirable one, but some statements appear with which I cannot agree. The Hundred-foot sand, described by him, in the Sewickley quadrangle, underlies "thousands of square miles in western Pennsylvania and Ohio." It also extends southward into West Virginia. In southwestern Pennsylvania and in West Virginia it is broken up into the Gantz sand and the Fifty-foot sand, separated by a bed of shale. Both these sands may be productive of oil in a single well. Everywhere throughout the area in which the Hundred-foot sand, or its constituents, produce oil, it consists of a well-defined sandy group occurring at what is supposed to be the very bottom of the Carboniferous system. Directly below the Hundred-foot, or the Fifty-foot sand, are found the Catskill red shales, which are easily recognized by the drillers.

"Scores of pools have produced, and are producing, oil from the Hundred-foot sand, but many times as many are producing from other sands lying below and above the Hundred-foot. Whatever conditions affect the accumulations of oil in one sand must be factors of greater or less importance in all of them; but the differences in character of the sand and other rocks, and the oil, gas, and water existing at different places in them, frequently produce structural relations which might appear, at first thought, to be entirely contrary to conditions in other pools with which the operator may be familiar. The Berea, or Thirty-foot, sand, lying at an average distance of 150 feet above the Hundred-foot, is of much wider extent as a productive sand than is the Hundred-foot.

"The Hundred-foot sand is the chief productive horizon in the Sewickley quadrangle, and is also productive a few miles west, in the eastern part of the Beaver quadrangle. In the western and northern parts of the Beaver quadrangle the Berea sand is productive, and the Hundred-foot, though present, has not yet been found to contain oil, although many holes have been drilled to it.

"The oil pools in the Beaver quadrangle, and in the quadrangles north and west of it, occur in thin "pay-streaks," as in the Sewickley quadrangle, and certain features, including the general character and distribution of the "pay-streaks," agree with those described by Mr. Munn. As found elsewhere, there are some dry areas several miles in extent, which lie directly down-dip from important pools of oil or of salt water or of both. For instance, near the corner of Brighton, Chippewa and South Beaver townships, in Beaver county, is a small pool in which the production of the wells is so light that they are not worth pumping, producing at best only a barrel or two a day. This pool is bordered on the northeast, southeast and south by a number of strong salt water wells. Contrary to the expectation of the operators, this pool was not found to lead to a stronger one near by, the dips of the rocks being too gentle to form any strong accumulation. The "pay" here, as in most pools of the Berea sand, is near the top of the sand. The salt water in close proximity to the pools occupies a definite structural position with reference to it, occurring on all sides of the pool except on the up-dip side. However, this water was not found to extend far southeast of the pool, several wells between there and Ohio River, four miles southeast, having been dry of water and oil. Similar occurrences are found repeatedly in the Berea sand in the Beaver and Newcastle quadrangles in Pennsylvania and in the Steubenville and Wellsville quadrangles in West Virginia and Ohio, where dry sands occur on the down-dip sides of pools of oil and of salt water.

"I can not agree with Mr. Munn that "the evidence as a whole is decidedly against the idea that the pools could have been accumulated by difference in gravity of oil and salt water." Everywhere, within a particular pool, where gas, oil and salt water are present, the gas occurs *above* the oil, and everywhere the main pool of salt water occurs *below* the oil, not directly underneath, but at right angles or at an acute angle down-dip. Although "lateral movement through difference in gravity alone," may, during historical time, have been "so limited as to be of no consequence," I have been obliged to dismiss all assumptions of the oil having been accumulated without regard to structure, and consequently gravity.

"A point to be noted in pools a short distance west of those described by Mr. Munn is that the lowest oil pool in the Berea sand in a given group of pools is successively higher above sea-level going from southwest to northeast parallel with the Ohio River. Near Steubenville and Mingo, in Jefferson county, Ohio, the lowermost elevation of the oil yet discovered in this sand is 600 feet below sealevel; at Holliday's Cove, West Virginia, it is about 400 feet below sea-level; on the West Virginia-Pennsylvania line near the southwestern corner of Beaver county, it is 250 feet below; at Hookstown and Smith's Ferry, Beaver county, it is at sea-level; while near the corner of Brighton, Chippewa and South Beaver townships it is 200 feet *above* sea-level. This progressive rise is not explained by Mr. Munn's theory, but it is explained in part by the greater general height of the anticlinal folds and the lesser depth of the adjacent synclinal depression toward the northeast.

"At the time the oil sands and intervening strata were deposited as sediments in the sea, the pores of all sandstones and other porous rocks must have been saturated with salt water. Through some cause, most of the water seems to have disappeared, leaving only scattering pools of it still present. We may fairly question, however, whether the harder and closer-grained portions of the Berea and Hundred-foot sands, where they are reported by drillers as dry, are in reality as dry as they appear to be, or whether they seem so owing to their lack of porosity. The fact that the still deeper oil sands, below the Hundred-foot, yield troublesome water much less frequently than do the upper ones, that they require no casing, and that the drillers seldom report water from them, indicates that most parts of these sands, whatever their texture, are really dry, and this view is in accord with the best data in deep mines, *i. e.,* that rocks below 1,000 feet or so are commonly dry of water. Whatever the cause of the real or apparent dryness of portions of the upper sands, the salt water, accompanied by whatever oil may have been present in any beds, was concentrated by rock pressure, molecular attraction, seepage, hydraulic pressure and other causes, and accumulated to a great extent in the more porous portions of the sandstones (in the "pays"). In deeply-buried sands the pressure alone would account for the segregation of the oil and salt water in the "pay streaks."

"Most of the "pays" in which the oil and salt water are found are many miles in extent, and the accumulations could not have been sufficient for economic development at any particular point in a sand or "pay," were it not that the rocks were subsequently tilted. The truth of this statement is manifested particularly by an area covering large portions of several counties fronting on Ohio River in southwestern West Virginia, in which conditions are otherwise favorable, where the dips are so slight that only shows of oil and gas have been obtained by drilling. Where the oil was concentrated into pools it was assisted by tilting of the rocks, which gave a partial or entire anticlinal structure. In each individual porous lentil, or "pay-streak," the oil, water, and gas occupying it and the closer-grained rock in proximity to it, were arranged according to their specific gravities at the lowest point on the down-dip side of the "pay-streak." The deposits could not be arranged in any other way. The fact that a so-called "pay-streak" lying down-dip from a known pool may be dry of both water and oil does not disprove the anticlinal theory in its proper application; but its position is due to the fact that whatever water and oil may once have occupied the "pay-streak" have been drained out or segregated elsewhere, naturally or artifically, or that the streak is not in reality so porous as would seem from the size of grains in the sand-pumpings. The arrangement of the grains, and the proportions of different relative sizes, are more important in determining a "pay" than is their absolute size."

FREDERICK G. CLAPP.

The Burning-Springs, or Volcano Anticlinal of Wirt, Wood, and Pleasants counties, W. Va., is the one in which geologic structure so strikingly dominates the occurrence of the oil and gas pools that when the late Prof. E. B. Andrews of Ohio, first walked along its crest in 1860 to 1861 and saw a line of oil and gas pools occupying the domes of this great uplift from Burning Springs on the Little Kanawha river through Wirt, Wood, and Pleasants counties to the Ohio river, 30 miles distant, his mind at once grasped the idea of the structural theory, and he wrote his views on this question from Marietta, dated March 20th, 1861, as subsequently published in the American Journal of Science 2, XXXII, 85, under the title of "Rock Oil, Its Geological Relations and Distribution," in which structure was recognized as the dominant factor in oil and gas accumulation. This Burning Springs arch varies greatly in direction, as shown by Prof. Grimsley and Mr. Hennen, my assistants, and is crowned at the top by a more or less flattened crest, one-half to one mile in width which is worked into a series of domes about which the oil and gas accumulations have taken place, the intermediate depressions being generally barren. On the western side of the uplift the dip breaks off suddenly at angles of 30° to 50°, and on the eastern slope, at the rate of only 20° to 30° and frequently less. Water usually fills the sands on the steep dips outside of the "oil break" as the crest of the arch has long been locally called, and often the saddles along the crest.

Until the present year the southern extension of the Burning Springs arch had not been traced beyond the Little Kanawha river, but during the past Summer, my assistant, Mr. Ray V. Hennen, in prosecuting the detailed survey of Wirt, Calhoun, and Roane counties, has followed its sinuous course dying down to an arch of moderate amplitude, and passing southwestward through the recently developed Walton oil pool of southern Roane county, where one of the largest fields in the State has been developed, so that this great arch has now been proven oil and gas bearing in the domes along its crest and more moderately dipping slopes for nearly 70 miles through West Virginia, while a great pool of salt water extends along the bottom of the rapid western slope of this arch through Pleasants, Wood, Wirt, Jackson, Roane, Mason, and Putnam counties, in which only slight showings of oil and gas occur, and only one or two insignificant pools have yet been opened, although more than 200 test wells have been drilled in this large area at widely scattered points.

The "Salt Sand," Big Injun, and Berea sands, so productive of oil and gas along the Burning Springs arch, are present as coarse and porous reservoirs over most of this extensive area between the Ohio river and the western base of the Burning Springs arch. Its oil sands have very little relief, and they are filled with salt water in which a little oil and gas is nearly always found. If the "anticlinal" or structural theory is not the prime factor in the accumulation of oil and gas into pools of commercial value, why is it that here where all other conditions,—porous reservoirs, thick and impervious cover, and the actual oil and gas—are present, and yet no large accumulations have taken place? The only plausible answer possible, it seems to the writer, is the absence of the necessary structural or "anticlinal" waves which would permit the segregation and separation by gravity of the oil, gas, and water, and thus permit it to accumulate into pools of commercial value.

I. C. WHITE,
Morgantown, W. Va.

December 20th, 1909.

GEOLOGY OF THE OIL AND GAS FIELDS OF THE SEWICKLEY QUADRANGLE.

By M. J. MUNN.

INTRODUCTION.

The State of Pennsylvania, in cooperation with the United States Geological Survey, is making a detailed study of its deposits of petroleum and natural gas.

Geologists have always maintained, and all producers now agree, that these pools do not occur by chance, but are the result of the action of natural forces, some of which, at least, are fairly well understood. Oil men everywhere are coming more and more to appreciate the fact that the science of geology offers the only natural explanation of many intricate problems connected with the location and exploitation of these products; because geology attempts such a solution by the simple, direct method of collecting and classifying all the available facts in their natural sequence, and thereby piecing together an authentic history of the oil and gas from the time it was formed until it is discovered by the drill. Only by such a method can we hope to determine the natural laws through which these results have been obtained.

In attempting this task the geologist has as his guide the geologic truths that have been established regarding the earth's history, and also the facts regarding the origin and mode of occurrence of petroleum and natural gas that have been discovered by previous investigators who have studied different phases of this subject in the various fields of the United States and elsewhere This is the solid, substantial foundation upon which all profitable investigations of this subject must be based, and only from this can the producer hope to receive material aid in his business attempts. When he fully appreciates this fundamental fact, and lends his unanimous endorsement and business acumen to the support of such efforts, the progress made by geology along this line will be as astonishing as it is gratifying. And when the producer comes to fully appreciate geology as an asset to be fostered and protected in the same manner as the other parts of his business machinery, he will find in it one that will grow more and more valuable from year to year.

At present one of the principal objects of this work is to collect, discover, and arrange such data relative to the laws of accumulation as will clearly show the part each played in bringing together these immense collections of oil and gas. For this purpose it has, therefore, been thought best to first study the well developed oil and gas producing areas where most facts are available, from which must be reasoned out the geologic history of those accumulations.

Another object is to show means by which a practical application may be made of the knowledge acquired in such a study to the search for undiscovered pools.

Producers everywhere consciously or unconsciously ask themselves two questions: (a) Where shall I drill for new production? (b) How much oil (or gas) will my wells eventually yield? These two problems are of paramount importance to operators in Pennsylvania, since the tremendous drain on the oil and gas resouces of the State for the last thirty years has so depleted the possible productive territory that its yield can not keep pace with the demand. The available territory in which new pools of oil and gas may be found has become less and less each year until now it is divided into isolated areas, in which there is little hope of the discovery of more great pools similar to those which gave Pennsylvania her prestige as an oil and gas producing State. In the future the producer must therefore expect to find, in an ever increasing ratio, less and less oil and gas for each well drilled. This means a very greatly increased cost of new production from year to year, which to be profitable shall require (1) a proportional increase in price of the oil or gas; (2) a decrease in the cost of drilling; (3) an increase in the efficiency of the wells drilled; or (4) a combination of all these factors. A discussion of the first two of these is without the province of this paper; the accomplishment of the third is the principal economic object of the work.

As regards estimates relative to the total production of wells, the writer is of the opinion that very valuable laws of flow of oil and gas wells, are easily within the reach of scientific investigators. It is possible that with the initial closed pressure, initial capacity, porosity and thickness of pay sand, initial ratio of oil to water, (if any), and a detailed history of the ratio of decrease of wells over a period of years, or until they are exhausted, etc., of a large number of wells producing from different sands over the Appalachian region; the geologist would be able to work out a table of capacities, dependent on factors easily determined by the producer. This would enable him to estimate within a very small limit of error the total production of a given well within a short time after it comes in, and also calculate closely the time required to exhaust the well. Scientific work of this nature can be carried on successfully only with the enthusiastic and confident support of a large number of operators.

At present investigations have been made, and a series of papers is being prepared on four fifteen minute quadrangles, covering over a thousand square miles of the oil region of Pennsylvania. Of these reports the present one of the Sewickley quadrangle is the first; similar bulletins for the Clarion, Carnegie, and Foxburg quadrangles will follow in the order named as rapidly as they can be prepared. Though these may be published by either the United States Geological Survey, or by the Topographic and Geologic Survey of Pennsylvania as the need arises, the general scheme of investigation and presentation followed herein will be preserved whenever practicable.

Within the territory named are some of the greatest oil and gas pools yet discovered in Pennsylvania. Thousands of deep wells have been drilled therein, which range from a few hundred to over 4,500 feet in depth. In drilling these wells geologic data of tremendous importance have been uncovered. Through carelessness and ignorance regarding the value of these facts most of them have been lost beyond hope of recovery. Of the remaining data still available on the Sewickley quadrangle, the writer has assembled all that could be secured in the time allotted to this work. Though by no means complete, it is believed that this information is of sufficient value to justify a somewhat detailed discussion. Among these data are more than a thousand records of wells as kept by the drillers. A careful study of these logs has evolved almost endless detail, but it is belived that from them, incomplete as they are, much value has been secured.

The author wishes to acknowledge his indebtedness to thousands of residents throughout the area examined, for their universally courteous and friendly answers to his inquiries. Special acknowledgment is made to the officers and employees of the several hundred oil and gas companies that operate in this territory. It was only through the open-hearted cooperation of these gentlemen in furnishing records of wells, and practically all the other data collected, that this report has been made possible. Personally, the author wishes to express his grateful appreciation of the expressions of encouragement and good will with which invariably he has been received by the oil and gas fraternity throughout this territory.

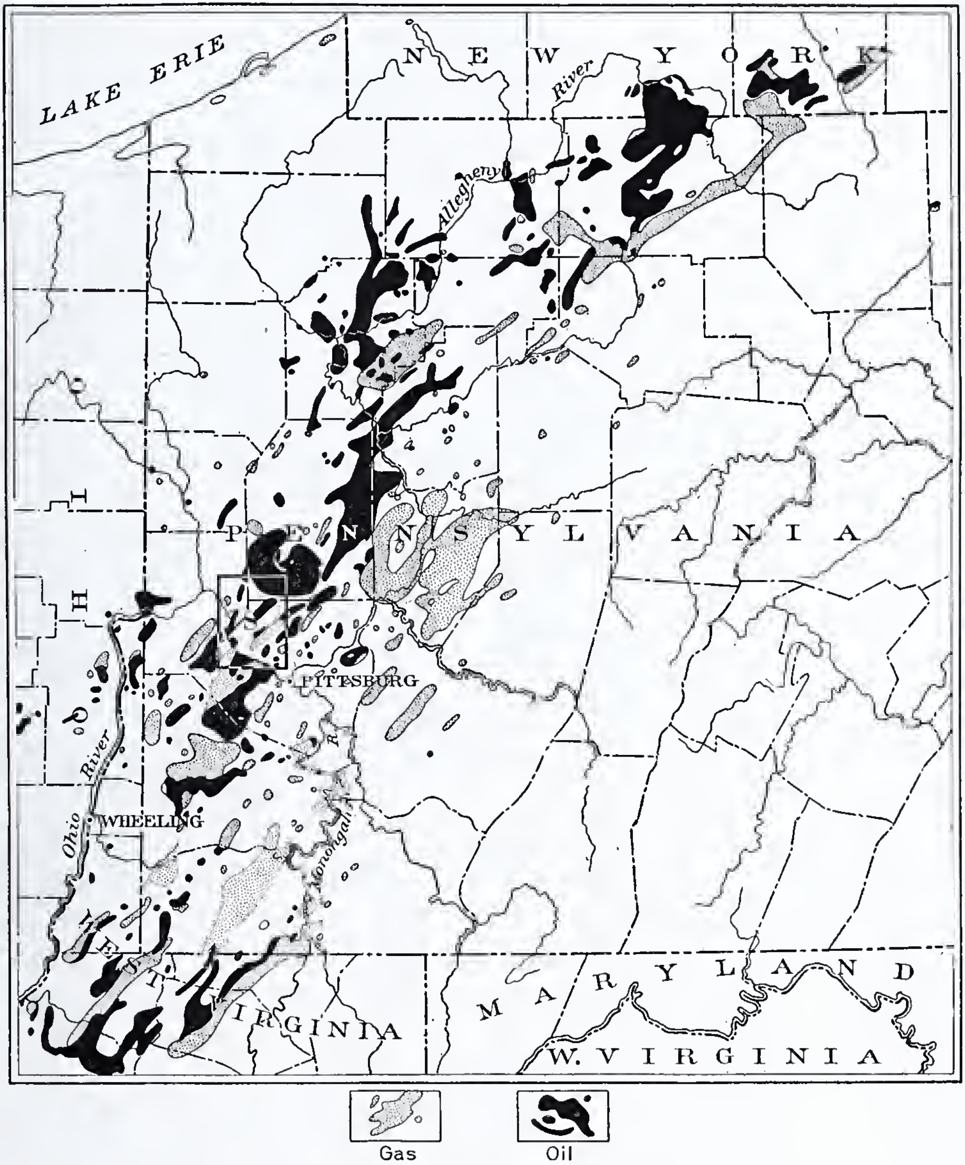
DESCRIPTION OF SURFACE.

LOCATION.

The Sewickley quadrangle embraces an area of about 227 square miles in the southwestern part of Pennsylvania. It is a quadrilateral bounded by the parallels 40° 30′ and 40° 45′ N., and meridians 80° and 80° 15′ W., and includes parts of three counties, the northern portion of Allegheny, the eastern part of Beaver, and the southern third of Butler. The southeast corner of this quadrangle lies about 5 miles north of Pittsburg, and its southwest corner is 1 mile southwest of the village of Moon; its northwest corner 3 miles west and a little north of Unionville; its northeast corner about 2½ miles east of and three-fourths of a mile north of Callery. The eastern border crosses the B. & O. R. R. a short distance east of Downeyville, and the western border passes through the town of Freedom.

TOPOGRAPHIC FEATURES.

This quadangle lies wholly within the basin of the Ohio river and embraces that portion of this stream which lies between the head of Neville Island and the town of Freedom. Almost the entire southern half of the quadrangle and the southwestern third of the north half are drained by short rapid streams flowing into this river. The larger of these tributaries on the north side of the river are Crows Run, Big and Little Sewickley creeks, Lowrys Run, and Pine Creek; on the south side of the river Montour Creek, Thorn Run, and Mehaffy Run, carry most of the drainage. The remainder of the quadrangle is drained by Brush Creek and Break-neck Creek, both of which flow northwestward to the Connoquenessing, thence to Beaver river, which empties into the Ohio west of the Sewickley quadrangle. The streams of this area flow in valleys from 100 to 500 feet below the tops of the adjacent hills. Brush and Break-neck creeks are more sluggish and have carved wider and flatter valleys than those streams emptying directly into the Ohio river. Many of the valleys of the latter are very narrow, the sides of which sometimes rise precipitously from 100 to 200 feet. During the time in which the present streams of the Sewickley quadrangle have been at work carving out their valleys the crustal movement within this area has been one of almost continuous though spasmodic, uplift. This variation in the rate of movement had a direct effect upon the eroding powers of the streams, and was so graphically recorded by them both in terraces and peneplanic



MAP SHOWING DISTRIBUTION OF OIL AND GAS FIELDS IN WESTERN PENNSYLVANIA AND ADJACENT TERRITORY

The location of the Sewickley quadrangle is shown by the rectangle marked S

horizons that despite subsequent erosion these distinctive topographic features are still clearly marked over a large portion of the quadrangle.

STRATIGRAPHY.

The rocks of Sewickley quadrangle are of sedimentary origin, that is, they were formed from sediments laid down under water. Each stratum is a more or less continuous sheet, spread out over large areas. The composition and thickness of these strata may vary from point to point because of differences in the local conditions of the body of water in which they were deposited, whereby the materials from which the rocks were formed were laid down in different proportions.

ROCKS EXPOSED AT THE SURFACE.

The rocks exposed at the surface on the Sewickley quadrangle are about 800 feet thick. They are all of carboniferous age with the exception of local deposits of silt and gravel belonging to the Quaternary (Pleistocene and Recent) period, which form a thin blanket over the older rocks along the valleys of Ohio river and some of the principal creeks The section of exposed rocks of Carboniferous age include the base of the Monongahela formation, all of the Conemaugh, having a thickness of about 520 feet, and about 180 feet of the Allegheny formation. These rocks consist principally of sandstones and shales, but have occasional thin beds of coal, limestone, fire, and flint-clays. This section includes no less than ten coal horizons, but most of these are of little, if any, commercial importance within the quadrangle.

The great gash cut by the Ohio river across the old peneplane surface in the southern portion of the quadrangle furnishes the best and lowest exposures of the outcropping rocks. Northward from the Ohio the beds rise slowly to the valleys of Brush and Break-neck creeks. These valleys are flat and the adjacent hills, well rounded and deeply covered with mantle rock, show few good exposures. Owing to the comparatively long distance from base level these streams have barely cut through the Conemaugh formation, and the Allegheny formation is therefore exposed in the quadrangle only for a short distance up these streams and along the Ohio river valley.

MONONGAHELA FORMATION.

These rocks between the top of the Waynesburg coal and the bottom of the Pittsburg coal are included in the Monongahela formation. Within the Sewickley quadrangle only about 100 feet of the lower portion of this formation remains on the tops of the highest hills. An unknown thickness of rocks in and above this formation has been disintegrated and carried away by the streams The largest areas still remaining are situated along the high ridge from Carnot to Moon, in the southwestern part of the quadrangle, and on a high knob about two miles west of Coraopolis. North of the Ohio river five isolated knobs carry from one to five acres of this formation. The Pittsburg coal at the base of the Monongahela formation here has a total thickness of from 10 to 14 feet, and a workable bed of about 6 feet. Above this coal are thin-bedded sandstones and shales.

CONEMAUGH FORMATION.

This formation includes all the rocks between the bottom of the Pittsburg coal and the top of the Upper Freeport coal, covering a vertical distance of 500 to 520 feet. The rocks of this formation cover the entire surface of the quadrangle, with the exception of that occupied by the Monongahela and a narrow strip along the valley of the Ohio river from Coraopolis westward, and similar strips in the valleys of Crows Run, Brush Creek, and Break-neck Creek. Below the Pittsburg coal are yellowish sandy shales and thin-bedded sandstones for 60 to 75 feet, in which are imbedded two or three thin grayish limestones,—Pittsburg limestone,—which are usually from 1 to 3 feet in thickness. This shale is underlain by a thin-bedded reddish shaly sandstone, the Connellsville, which varies from 10 to 75 feet in thickness Its maximum thickness is apparently due to changes of the overlying beds from shale to sandstone.

Below the Connellsville sandstone are reddish sandy shales down to the top of the Morgantown sandstone (or "Murphy sand" of the drillers) of southwestern Pennsylvania. This bed is from 40 to 100 feet thick. Its base ranges from 200 to 225 feet below the bottom of the Pittsburg coal. The layers at the bottom of this bed are thickest; those at the top grade into reddish shales. Underlying the Morgantown sandstone is from 15 to 30 feet of soft yellow and red shales to the top of the Ames limestone.

AMES LIMESONE.

This limestone which is from 230 to 245 feet below the bottom of the Pittsburg coal, consists of two or three layers, with a total thickness of from 0 to 4 feet. In color it varies, according to its purity, from gray to light pink to greenish yellow. When of the latter color the bed is scarcely more than a calcareous shale. Wherever found it is highly fossiliferous, the purer forms being packed with branchiopods and crinoid stems. This limestone outcrops about half way up the river hills opposite the head of Neville Island, and may be traced in continuous crop along both sides of the river and the valleys of tributaries, from that point westward to

Baden, at which place the northwestward rise of the rocks brings it well up towards the tops of the highest ridges. This bed is present in outcrop over a large portion of the Sewickley quadrangle (see pl. V.) and its lithological characteristics are so distinctive that it can always be recognized at a glance. For these reasons it was selected as the horizon from which to make a structural map of the outcropping rocks. Contrary to the usual occurrence, the interval between the limestone and Pittsburg coal increases from south to north across the quadrangle.

Below the Ames limestone is from 10 to 30 feet of red rock underlain by reddish shales, in which occur two or three thin coal seams, and occasionally reddish, thin-bedded sandstone lentils from 5 to 75 feet in thickness. The most widespread of these sandstones is one which is probably correlated with the Saltsburg sandstone ("Little dunkard sand," of the drillers). This bed varies from a coarse, reddish, sandy shale, interbedded with thin sandstone layers, to a massive sandstone 25 to 60 feet thick. The top of this sandstone is from 340 to 370 feet below the Pittsburg coal.

The most prominent sandstone of the Conemaugh occupies an interval of from 20 to 100 feet at the base of the formation. This is the Mahoning sandstone ("Dunkard sand" of the drillers). In the Sewickley quadrangle it is most always in evidence wherever this horizon comes to the surface. The lower ledges are usually massive, single ones sometimes reaching a thickness of 20 feet. Upward, the layers become thinner, grading at the top, into reddish shales. This sandstone bed, with the exception of 15 or 20 feet at the bottom, has sometimes been traced into sandy shale within a few hundred yards along an exposed crop. This accounts for the great variation in thickness of the Mahoning sandstone ("Dunkard sand") as reported in well records; and what is true of this sandstone is applicable in a more or less degree to every other one encountered by the driller.

ALLEGHENY FORMATION.

The Allegheny formation extends from the top of the Upper Freeport coal, which is at or near the base of the Mahoning sandstone, down to the top of the Homewood sandstone, or what is probably equivalent to the "Gas sand" of the drillers of southwestern Pennsylvania. The upper half of this formation is exposed in a very limited portion of the Sewickley quadrangle. Where exposed the outcrops are poor, and data regarding the rocks of this formation are meager. These beds have been carefully studied in the Beaver quadrangle by Woolsey, *(a)* who notes the Butler sandstone and its accompanying shales from 35 to 85 feet thick, the top of which lies from 3 to 16 feet

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(a) U. S. Geol. Survey Bull. 286 and Folio No. 134.

below the top of the Freeport coal. The next prominent sandstone horizon (the Freeport sandstone) occurs from 50 to 130 feet below the Freeport coal, or 575 to 650 feet below the bottom of the Pittsburg coal. The Freeport sandstone has a thickness of 35 to 60 feet, but like that of the Mahoning and Butler, is frequently occupied by shales and thin sandstone "shells." Between these two sandstone horizons and down to a few feet below the Lower Kittanning coal, are shales and clays interbedded with three or four coal seams and several limestones, some of which attain a local thickness of 6 or 7 feet. A somewhat prominent sandstone lies immediately below the Lower Kittanning coal, and is the lowest horizon exposed at the surface within the quadrangle. It crops along both sides of the river at Freedom and continues above the level of the river to a short distance east of Conway.

Below are given a few typical road and ravine sections taken in different parts of the quadrangle, from which a good idea may be had of the rocks encountered:

Section in ravine on the south side of Ohio river, one-fourth mile east of Stoops Ferry.

	Feet
Sandstone, Morgantown, about	100
Shale, yellowish, ...	5
Shale, red, ...	3
Shale, yellow, ...	5
Limestone, Ames, ...	5
Shale, yellow, ...	3
Shale, red, ...	10
Concealed, ...	34
Limestone boulders apparently in place; closely resembles Ames, but thinner, ...	1 or 2
Shale, red, ...	8
Sandstone, clay, shale, and limestone debris,..	8
Sandstone, reddish, thin-bedded, ...	40
Shale, blackish to brown, sandy, ...	30
Sandstone, ...	3
Shale, blackish to brown, ...	12
Sandstone, ...	3
Shale, blackish to brown, ...	12
Limestone, black, fossiliferous (slightly),......	2
Shale, black, ...	5
Coal, Gallitzen (?)	1 or less
Shale, reddish, ...	2
Sandstone, probably Mahoning, ...	10
Concealed, ...	———

A few yards west of Stoops Ferry the following section was taken:

Section up hill west of Stoops Ferry.

	Feet
Concealed,	—
Shale, brown to reddish; (prominent cleavage planes),	20
Concealed,	25
Shale, reddish,	8
Coal, Gallitzin,	1
Shale, reddish,	5 to 25
Sandstone, Mahoning; 20-foot layer at bottom,	50
Concealed,	—

A section taken along the pike from top of the hill south of Carnot northward toward Stoops Ferry, shows the rocks encountered between the Pittsburg coal and the Ames limestone in this vicinity:

Section along pike from top of hill south of Carnot north toward Stoops Ferry.

	Feet
Sandstone debris on top of hill,	30
Pittsburg coal smut,	—
Shale and sandstone debris,	12
Limestone, about	1
Shale, greenish,	4
Shale, yellow,	5
Concealed,	10
Shale, yellowish, sandy,	70
Sandstone, gray to reddish, thin-bedded,	10
Shale debris, reddish,	30
Sandstone, Morgantown, gray, thin-bedded,	60
Shale, coarse, blocky,	7
Shale, red,	8
Shale, soft, light-yellow,	5
Limestone; Ames, light-gray, fossiliferous,	2

The Ames limestone in the above section is in bottom of run at the point where an elevation of 990 is given on this bed, Plate V. Half a mile northeast of this point where the elevation of this limestone is marked 985, a section was made of the rock exposed along the road below the Ames, which connects the above sections in such a way as to give a fair section of the Conemaugh formation in this vicinity:

Section on road to east of pike 1 mile south of Stoops Ferry.

	Feet	Inches
Clay, yellow, ...	1	
Shale, very deep red, ...	3	
Shale, yellow, ...	2	
Limestone, Ames, ...	1½	or less
Shale, red clayey, ...	10	
Concealed, ...	15	
Clay, yellow, ...	1	
Concealed, about, ...	20	
Limestone (may not be in place), ...	1	
Sandstone debris, about	40	
Shale, reddish brown, ...	20	
Limestone, black, ...	——	4-6
Shale, reddish, ...	6	
Limestone, yellow, nodular, fossoliferous,..	1	to 1 ft. 6 in.
Shale, brown, ...	15	
Shale, reddish, ...	5	
Clay, white, about	1	
Sandstone, reddish, thin-bedded, ...	——	
Concealed, ...	——	

A section taken on the road south from the elevation marked 990 in the central part of Kilbuck township gives a typical example of the rocks exposed in this area:

Section in central part of Kilbuck township.

	Feet	Inches
Limestone, Ames, fragments, ...	——	
Shale, debris, (red), ...	20	
Concealed, ...	14	
Shale, reddish, sandy, blocky, ...	21	
Shale, yellowish, blocky, ...	3	
Sandstone and shale, ...	5	
Shale and clay, reddish, ...	16	
Sandstone, bluish, thin-bedded, ...	10	or more
Shales, sandy, with thin layers of sandstone,.	17	
Shales, reddish, blocky, with thin layer of sandstone, ...	10	
Shale, soft, clayey, dark, ...	10	
Limestone, black, fossiliferous, three layers,....	1 to 2	
Shale, dark, ...	2 to 3	
Coal, ...	——	6
Clay, mealy, brown and greenish, ...	11	

	Feet	Inches
Shale, reddish, blocky,	11	
Sandstone, Saltsburg (?)	50	
Shale, reddish,	6	
Coal, (?) Gallitzin,	1	or less.
Sandstone a short distance below,	———	
Concealed,	———	

In the western portion of the township the following sections show the lower part of the Conemaugh and the upper part of the Allegheny formation:

Section on road north from Rehobeth church, Economy township.

	Feet	Inches
Sandstone, Morgantown (top of hill)	60	
Shale, very deep red,	5	
Shale, yellow,	10	
Limestone, Ames,	3	
Shale, red,	20	
Shale and clay, reddish,	20	
Shale, brown, sandy,	40	
Shale, dark,	18	
Limestone, nodular, fossiliferous,	1	or less.
Shale and clay, blue and red,	10	
Sandstone, reddish, thin-bedded,	20	
Shale, brown to reddish, with thin sandstone lentile,	65	
Concealed, about	25	
Sandstone,	30	
Shale, coarse, blue,	2 or 3	
Coal, Upper Freeport (?)	1	or less.
Shale, reddish to yellowish, carrying sandstone lentils,	20	
Shale, bluish to concealed,	4	

Section up Freedom Hill on western edge of quadrangle in SW cor. New Sewickley township.

	Feet	Inches
Shale, reddish, sandy,	8	
Sandstone, Mahoning, thin-bedded and reddish at top; massive at bottom,	55	
Shale, yellowish,	15	
Shale, bluish,	8	
Shale, black,	5	
Coal, Upper Freeport	1	

	Feet	Inches
Shale, reddish, with thin lentils of sandstone,	40	
Sandstone, massive in places and with numerous false bedding planes, ...	40	
Coal, Upper Kittanning (?), ...	—	8
Shale and clay, ...	15	
Sandstone, partially concealed by terrace gravels, ...	35	
Shales, reddish to grayish, sandy to concealed..	35	

Section on road one-fourth mile south of Unionville.

		Feet	Inches
1.	Sandstone debris below top of hill, ...	30	
2.	Sandstone, ...	10	
3.	Shale, light brown, ...	25	
4.	Limestone, black, ...	1	
5.	Shale, light brown, ...	5	
6.	Clay, dark to reddish, ...	10	
7.	Coal, Gallitzen (?) Brush Creek, ...	1	6
8.	Shales and sandstones, dark to reddish, ...	15	
9.	Shale, dark, ...	5	
10.	Shale, reddish, ...	5	
11.	Shale, dark, ...	4	
12.	Coal, ...	—	0 2
13.	Shale, coarse, bluish, ...	10	
14.	Coal, ...	—	0 2
15.	Shale, reddish, ...	10	
16.	Clay, greenish, ...	8	
17.	Clay, white (flint?), ...	2	
18.	Shale, reddish, blocky, ...	22	
19.	Shale, dark, ...	1	
20.	Fire clay, ...	2	
21.	Clay, reddish, ...	3	
22.	Shale, reddish, ...	5	
23.	Sandstone, ...	3	
24.	Shale, ...	1	
25.	Fire clay, ...	3	
26.	Concealed (sandstone debris), ...	10	
27.	Clay, yellow and green, ...	2	
28.	Sandstone, massive yellowish, ...	15	
29.	Fire clay, yellow and white, ...	1	
30.	Coal, ...	1	
31.	Fire clay, yellow and white, ...	2	
32.	Shale, brown, blocky, ...	15	
33.	Concealed (sandstone debris 15 ft.)	—	

The above section varies very much from the one given below made on the same road half a mile farther to the north on the north side of Brush Creek:

Section on road one-fourth mile north of Unionville, New Sewickley township.

		Feet	Inches
1.	Sandstone, massive gray to yellowish, ...	25	
2.	Concealed; sandstone debris showing thin-bedded sandstone in places, ...	45	
3.	Shale, reddish to brown, blocky, ...	30	
4.	Shale, black, carbonaceous, ...	1	
5.	Shale, reddish brown, blocky, ...	33	
6.	Clay, reddish, ...	2	
7.	Shale, yellow, ...	2	
8.	Fire clay, green, ...	6	
9.	Shale, brown, ...	12	
10.	Sandstone, ...	5	
11.	Clay, dark, carbonaceous, ...	1	
12.	Fire clay, ...	5	
13.	Sandstone, thin-bedded (bluish), ...	30	
14.	Coal, ...	1	6
15.	Clay, reddish, ...	10	
16.	Sandstone to concealed, ...	15	

Where these two sections were taken the rocks are well exposed, and but little is needed to make them complete. Number 14 coal is probably the same as number 30 of the previous section, but the middle and upper portions seem to bear little detailed resemblance to each other.

The following section is taken just off the northeast corner of the quadrangle, and so far as it goes shows a typical exposure of the rocks below the Ames:

Section on road off the northeast corner of the Sewickley quadrangle.

	Feet	Inches
Limestone (Ames) boulders scattered on top of hill to west of road, ...	——	
Shale, red, clayey, ...	10	
Sandstone partly concealed, ...	25	
Coal, ...	1	6
Sandstone, thin-bedded, not well exposed, ...	8	
Sandstone and shale debris, ...	45	
Shale with thin sandstone lentils, reddish, ...	30	
Sandstone, thin-bedded, ...	10	

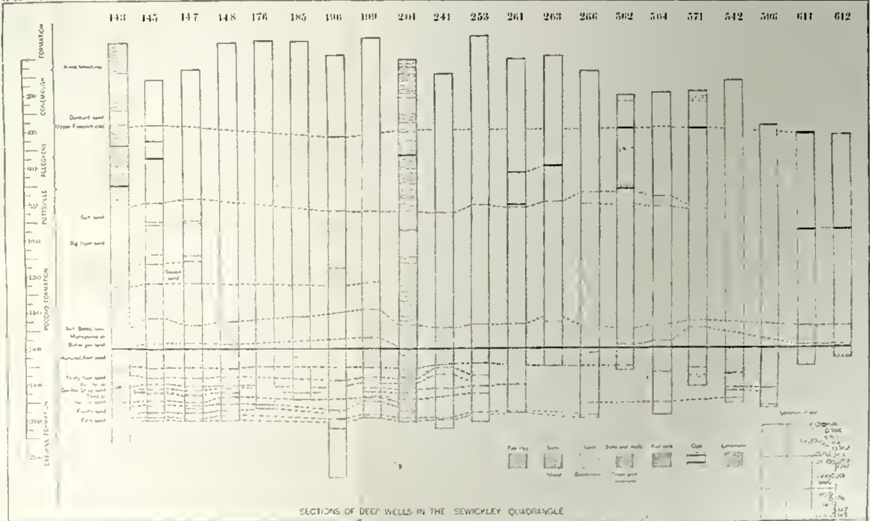
	Feet	Inches
Shale, brown, sandy,	45	
Sandstone debris,	40	
Sandstone, massive ledges,	8	
Sandstone debris,	32	
Concealed,	10	
Clay, light bluish,	10	
Sandstone, thin-bedded debris,	22	
Limestone, yellow (in bottom of creek),	———	

It will be noticed that little attempt has been made to correlate the beds given in the above sections. To do this more field work is necessary in areas where the rock exposures are poor. The subject of correlation is only incidentally treated in this bulletin, the detailed presentation of this data being reserved for publication later in the forthcoming folio of this quadrangle. It is believed that with the sections and descriptions given above, and the crop line of the Ames limestone shown on Plate V, the reader will have such data as he desires for practical field purposes.

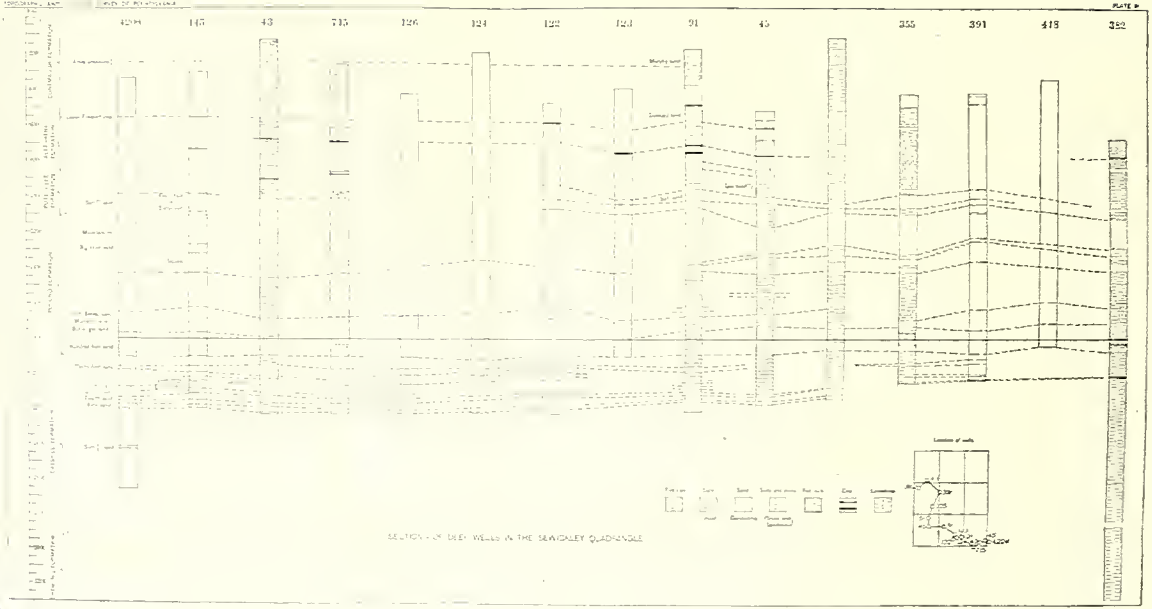
ROCKS NOT EXPOSED AT THE SURFACE.

All that is known of the rocks concealed below the surface on the Sewickley quadrangle has been derived from a study of these rocks by other geologists at points of outcrop, and from data furnished by logs of deep wells. Most of these drillings have been for oil or gas, and were made by the churn drill method, which does not permit of as close measurements or as detailed descriptions of the beds encountered as the geologist desires. Moreover, few drillers and tool dressers, the men who actually put down the holes, know much of the fundamental principles of geology, and the records which are usually kept of wells show little data except that relative to the practical side of the oil business. In detailed logs the driller records, with a fair degree of accuracy, sands (sandstones), slate (shales), and shells (thin sandstones interbedded with shales), limestone, redrock (red shale), and coal. He easily detects changes from hard to soft rock by difference in the rate of drilling and from the "feel" of the drilling cable. He notes changes in color and composition of the rocks by the relative wear of the bits, and the nature of the bailings. In most instances a trained driller can put down hole after hole in an area where the structure and topography materially change the geologic position of the mouth of each well, and still make records which when compared stratigraphically and structurally are found to be as consistent as the usual nature of the beds warrant.

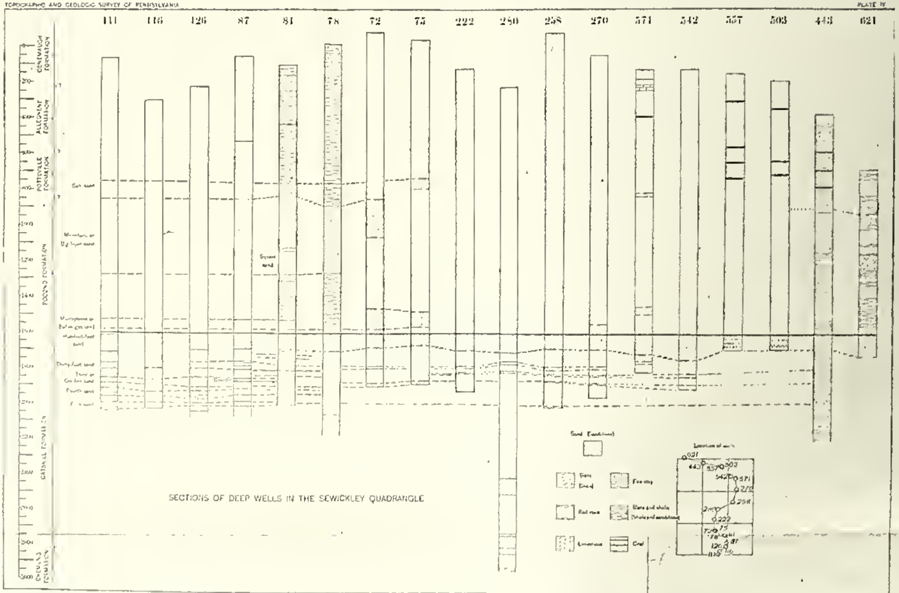
The greatest difficulty encountered by the geologist in attempting to use the data furnished by these records lies in the fact that drillers do not follow a uniform standard of classification for the rocks. Each



SECTIONS OF DEEP WELLS IN THE SEWICKLEY QUADRANGLE



SECTIONS OF DEEP WELLS IN THE SEWICKLEY QUADRANGLE



SECTIONS OF DEEP WELLS IN THE SEWICKLEY QUADRANGLE

driller classifies the material which he encounters in a well according to what he thinks it might be. If only one driller had operated in a given field, the geologists' task of correlating the rocks from his description would be an easy one. In most fields, however, the drilling has been done by a number of men gathered from various parts of the region, where the geologic conditions vary greatly, and each consciously or unconsciously tries to adopt the same nomenclature in the new field that he was accustomed to in the old. It is probable that if several such drillers were to keep independent records of the same well, these would vary considerably in the minor details. For this reason the geologist is forced to deal largely in generalties in his study of the stratigraphy of the underground rocks.

No oil or gas pools of commercial value have been found in rocks in or above the Allegheny formation within this quadrangle. The following table gives the sequence of the more important oil and gas sands recognized by the driller below this formation:

CORRELATION OF THE OIL SANDS OF THE SEWICKLEY QUADRANGLE.

Formation.	Driller's Name.	Geologist's Name.
Pottsville	Gas sand	Homewood sandstone
	Salt or Fortyfoot sand	Connoquennessing sandstone
Pocono	Mountain, or Big Injun sand Squaw. Papoose.	Burgoon sandstone.
	Butler gas, Butler 30 (?) foot, Gas, Salt, Murraysville, or Berea (?) sand.	
	Gantz and fiftyfoot or Hundredfoot sand.	
Catskill	Nineveh 30-foot or Thirty-foot sand.	
	Snee, Blue Monday, or Stray-stray sand.	
	Boulder, Gordon Stray, or Campbell Run (?) sand.	
	Gordon, or Third sand.	
	Fourth sand.	
	Fifth (McDonald) sand.	
	Bayard, or Sixth sand.	
Chemung ?	Elizabeth sand	
	Warren first sand. (?)	
	Warren second sand. (?)	

It will be seen from an examination of the records given below that the term "salt" and "gas" have been applied to a number of different beds. These are most widely applied, however, to the sandstone members of the Pottsville formation as given above, though in the Sewickley quadrangle the Kittanning and Clarion sandstones of the Allegheny formation are probably frequently erroneously called the Gas sand by drillers. In this paper no attempt will be made to correlate the oil sands of this quadrangle with those of adjacent areas, it being considered best to call attention to Plates II, III, and IV, on which are shown the sections of 54 wells plotted to a scale and arranged with reference to the top of the Hundredfoot sand as a datum plane. A careful comparison of these sections will give a fair idea of the difficulties encountered in making correlations. This is due to the fact that very few records show a complete section of all the rocks passed through, and it is therefore difficult to follow the succession of strata in different wells. This difficulty is seen to be greater when we consider that a very small portion of the horizontal distance covered by a line of sections across a quadrangle is actually represented by the rock passed through by the drill. We have no means whatever of finding out what lithologic changes take place in the beds from well to well.

These plates show three lines of sections of wells across the Sewickley quadrangle. They have been selected from nearly 1000 records of wells within the quadrangle, the selections being made with reference to location of each well and data shown by it. A casual glance at these sections reveals their incompleteness, and shows at the same time the difficulty encountered in tracing out the extent and thickness of important strata. In this work much care was taken to determine the horizon of the Hundredfoot sand, and it is believed that most, if not all of the sections are arranged correctly with reference to the top of this sand.

The following table gives the thickness of the oil sands and of the shale interval between each of them, also the distance between the top of each sand and the top of the Hundredfoot in a sufficient number of records to give fair averages:

Special attention should be called, however, to some of the plotted records. In well 143, Plate II, the Thirtyfoot sand, according to the record is 70 feet thick, with gas in the upper portion and oil 42 feet below. The bottom of this sand is mentioned as being 8 feet above the top of the Boulder, which here unites with the Third to make a sand 75 feet thick. In this case the upper sand might possibly represent both the Thirtyfoot and Snee sands, but judging from intervals from the top of the Hundredfoot to the top of the Snee, in wells 145 and 147, the Third, Boulder and Snee all seem to be represented in the lower of these sands.

Following the correlation lines of these four sands across this sheet in well 145, the bottom sand of the group is called the Boulder sand in the record, and the Third and Fourth sands are grouped together in the sand below. Also in the section of well 147, the Third and Fourth sands as given in the records, are enclosed by the correlation lines of the Fourth sand.

In section 148 this sand is given in the record as the Third, and the lowest sand as the Fourth. Continuing these lines to section 176, the record gives the sand as the Third, or Gordon. The bottom sand in well 185 is also mentioned in the record as the Third sand. Both these sands are oil-bearing in these wells, and from these data alone it looks as if well 176 is producing from the Fourth sand. In well 196 the thicknesses of the sands are not given, and hence the record is of little value. Sections 199 and 201 show normal conditions from the Hundredfoot through the Fifth sand. In 241 some doubt exists regarding the correlation of the first sand below the Hundredfoot as the Thirtyfoot. It may be in reality a local sandstone more closely associated with the lower member of the Hundredfoot northward. The Fifth seems to be the most persistent member of the Venango oil sand group, but beyond well 266, this bed also seems to pinch out.

Passing to Plate III, the first three sections illustrate very clearly the difficulty of settling conclusively from well records the correlation of the Third sand group. Well 420 H, McCallum & McGue No. 1, recognizes no Snee or Boulder sands. In the next section (145) shown of the W. H. Crider well No. 1, the first sand below the Hundredfoot is called the Thirtyfoot, the second Snee, and the one below it the Boulder. The one below this is called the Third and Fourth sands in the record. The chances are very much in favor, however, of the Third sand being combined with the Boulder in this well, as it is nearly at the Boulder horizon. This sand is given as Boulder and Third in well 143. Tracing these correlation lines across the plate, what is termed Third by the driller in well 715 seems correct, as it also apparently is in well No. 87. In well 124, which is the Dixmont property No. 14, what appears to be the top portion of this horizon is given as the Boulder and the record specifically states that no Third sand was found. The above is also true of No. 122, which is No. 15 on the same farm. In section 91 on the W. P. Snyder farm, the complete record of which is published on p. 42, the Third sand is given as 15 feet thick, with 25 feet of shale between it and the Fourth. Above the Third the Boulder is probably represented by the "sand shells." The remaining sections of this plate do not furnish data sufficient to justify closer correlations than are shown.

The sections of wells shown on Plate IV reveal the same discrepancies in an attempt to correlate the three members of the Third sand group as independent sandstones. It will be seen that the first three sections of this Plate mention no Boulder or Snee sands. In the Fourth section, which is of the E. M. Crawford No. 1 well (87), the first sand below the bottom of the Hundredfoot is given in the record as the Thirtyfoot, the second being called the Snee and the Third the Boulder, and 58 feet below the top of the Boulder 30 feet of sand is called the Third. From a comparison of all the records available on the point it is believed that this sand is really the Fourth sand, and the one below corresponds more closely with the Fifth. In section 81 of the J. Hohman No. 1 well, located about 1 mile east of Mt. Nebo Church, the Third and Fourth sands are doubtless correctly correlated, but there is a question as to the correct correlation of the three small sand beds immediately above the 75 feet of shale which here overlies the Fourth. The record of well 78 is incomplete, and shows nothing of importance below the Hundredfoot sand. Sections 72 and 75 are from the records of the John Wilson No. 1 and the S. H. Grubbs No. 7 respectively in the Grubbs oil field, and the lowest sand shown in these sections is the principal oil producer. There has been some doubt expressed by operators in this field as to the correct name for this sand. For the purpose of settling this point the writer has made comparisons of all the available records without being able to arrive at a satisfactory conclusion. The result is fairly portrayed on the plate. From all the stratigraphic evidence it seems probable that this is really the Third sand, instead of the Boulder, as is generally supposed, but this evidence is by no means conclusive.

DETAILED RECORDS OF WELLS ON THE SEWICKLEY QUADRANGLE.

The records given below have been selected for the purpose of giving an idea of what the best grade of records show of the underground stratigraphy. If the records of all the wells drilled on the quadrangle had been kept as accurately as possible, and with as much detail as these, and made available to the writer, the value of the geologic work covered by this report would have been almost infinitely increased.

WELL NO. 45.

EZRA P. YOUNG NO. 1, AT EDGEWORTH, LEET TOWNSHIP, Allegheny County.

Finished Sept. 24, 1900.
Altitude above sea level 705 feet.
Record furnished by E. P. Young.

	Thickness	From	To
Recent			
Sand and gravel,	56	0	56
Conemaugh			
Sandstone (Mahoning)	36	56	92
Slate, *(a)* very muddy,	6	92	98
Allegheny			
Coal (Upper Freeport)	2	98	100
Fireclay,	5	100	105
Slate, white,	15	105	120
Limestone,	10	120	130
Slate,	15	130	145
Fireclay,	5	145	150
Slate; some gas,	10	150	160
Sandstone and water,	8	160	168
Slate; coal gas,	5	168	173
Slate black,	70	173	243
Coal (Lower Kittanning?) some gas,	3	243	246
Slate,	30	246	276
Slate; gas,	5	276	281
Slate,	29	281	310
Limestone, gray (Vanport),	22	310	332
Sandstone, white,	30	332	362
Pottsville			
Slate,	47	362	409
Sandstone (?),	10	409	419?
Slate,	50	429?	479
Salt sand (?) with water,	33	479	512
Slate, black,	132	512	644

WELL NO. 45.—Continued.

Pocono			
Big Injun sand,	133	644	797?
Slate,	18	797	815
Squaw sand,	15	815	830
Slate,	38	830	868
Sandstone; gas,	35	868	903
Slate and shells [b],	104	903	1,007
Sandstone, black,	25	1,007	1,032
Slate and shells,	95	1,032	1,127
Bitter Rock sand,	36	1,127	1,163
Slate and shells,	47	1,163	1,210
Redrock,	60	1,210	1,270
Hundredfoot sand,	84	1,270	1,354
Catskill			
Slate and shells,	221	1,354	1,575
Third sand (Gordon) gas at 1,577,	12	1,575	1,588?
Slate,	33	1,588	1,621
Fourth sand and gas,	15	1,621	1,636
Slate to finish,	5	1,636	1,641
Total depth,		1,641	

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[a] Shale.
[b] Thin alternating beds of shale and sandstone,

In this record it will be seen that the sand 165 feet above the top of the Big Injun is called the Salt sand. The one next above is probably the Gas sand. Special attention is called to the rocks of the Pocono formation, as shown here. It will be seen that 60 feet of redrock (red clayey shale) overlies the Hundredfoot sand at this point.

WELL 143, PLATE II.

J. M. Allen, Ross Township, Allegheny County, located on the eastern edge of Westview.

Altitude 1087.
Record furnished by E. I. Baldwin.

	Thickness	From	To
Conemaugh			
Slate,	120	0	120
Lime,	10	120	130
Slate,	30	130	160
Sand,	110	160	270
Slate,	90	270	360
Sand,	80	360	440
Allegheny			
Slate,	25	440	465
Sand,	25	465	490
Slate,	70	490	560
Coal,	3	560	563
Lime,	10	563	573
Slate,	47	573	620
Sand,	15	620	635
Slate,	25	635	660
Sand,	40	660	700
Slate,	65	700	765
Coal,	4	765	769
Lime,	10	769	779
Pottsville			
Slate,	111	779	890
Big Injun,	440	890	1,330
Pocono			
Slate,	230	1,330	1,560
Salt (?) sand (Murrysville),	115	1,560	1,675
Slate,	16	1,675	1,691
Hundredfoot sand,	97	1,691	1,788
First pay,		1,710	
Second pay,		1,721	

WELL 143.—Continued.

Catskill			
Slate,	52	1,788	1,840
Thirtyfoot sand,	70	1,840	1,910
Gas,		1,851	
Oil,		1,893	
Slate,	8	1,910	1,918
Boulder sand,	35	1,918	1,953
Third sand (Gordon),	40	1,953	1,993
Slate,	31	1,993	2,024
Fourth sand,	41	2,024	2,065
Slate,	20	2,065	2,085
Fifth sand,	30	2,085	2,115
Slate,	3	2,115	2,118

WELL NO. 91.

W. P. Snyder No. 1, Sewickley Heights Township Allegheny County.

Altitude of well 1057. Record furnished by F. S. Crease.

	Thickness	From	To
Conemaugh			
Soil and gravel,	7	0	7
Sand (water),	30	7	37
Slate (Morgantown?),	15	37	52
Sandstone (Morgantown?),	20	52	72
Redrock,	25	72	97
Limestone (Ames?),	20	97	117
Slate,	15	117	132
Sandstone,	10	132	142
Redrock,	20	142	162
Limestone,	20	162	182
Slate,	15	182	197
Redrocck,	10	197	207
Slate,	18	207	225
8¼-inch casing,			225
Slate,	25	225	250
Limestone,	15	250	265
Slate,	20	265	285
Sand,	27	285	312
Coal (Gallitzin),	3	312	315
Slate,	25	315	340
Sand (Dunkard),	60	340	400
Allegheny			
Slate,	30	400	430
Sand (Freeport),	40	430	470
Slate and shells,	65	470	535
Coal (water),	4	535	539
Slate,	31	539	570
Coal and water,	5	570	575
Fire clay,	7	575	582
Limestone,	25	582	607
Slate (?),	30	607	637
Pottsville			
Sand,	25	637	662
Limestone,	15	662	677
Slate,	25	677	702
Limestone,	20	702	722
Slate (black),	15	722	737
Limestone,	10	737	747
Slate,	25	747	772
sixtyfoot sand (Salt?),	68	772	840
Casing 6¼ inches,			840
Slate and shells,	40	840	880
Pocono			
Big Injun sand,	300	880	1,180
Slate,	20	1,180	1,200
Sand,	30	1,200	1,230
Slate,	40	1,230	1,270
Sand,	15	1,270	1,285
Slate and shells,	145	1,285	1,430
Sand,	25	1,430	1,455
Slate,	15	1,455	1,470

WELL NO. 91.—Continued.

	Thickness	From	To
Sand,	15	1,470	1,485
Slate,	10	1,485	1,495
Sand,	10	1,495	1,505
Slate,	12	1,505	1,517
Sand (hard),	15	1,517	1,532
Slate and shells,	40	1,532	1,572
Redrock and shells,	20	1,572	1,592
Slate and shells,	25	1,592	1,617
Top Hundredfoot sand,		1,617	
Sand, slate and shells,	22	1,617	1,639
Show of oil,			1,640
Water,	29	1,640	1,669
Slate,		1,669	1,674
Bottom of Hundredfoot,	83		1,700
Slate and shells,	28	1,700	1,728
Catskill			
Cased with 4⅝,		1,724	
Slate and shells,	50	1,728	1,778
Sand and shells,	20	1,778	1,798
Slate and shells,	75	1,798	1,873
Sand sheils,	15	1,873	1,888
Slate,	22	1,888	1,910
Third sand (Gordon) (Gas),	15	1,910	1,925
Slate and shells,	25	1,925	1,950
Fourth sand,	6	1,950	1,956
Slate and shells,	19	1,956	1,975
Slate,	25	1,975	2,000
Slate and sand shells,	10	2,000	2,010
Slate,	8	2,010	2,018

Total depth, 2,018

Near the top of this record, it will be noticed that a limestone 20 feet thick has been questionably considered the Ames. This limestone is usually underlain by red shale or clay, and is never found in outcrop to be over 5 feet thick. In fact no limestones of the Conemaugh formation have been known to exceed that thickness within this quadrangle. It will also be noted that a 20-foot bed of redrock lies 45 feet above the top of the Hundredfoot. This is the highest red bed found below the Pottsville. Because of its position and wide extent it is one of the characteristic markers for the Hundredfoot sand.

WELL NO. 201.

Pierce No. 2 Located 2 miles Southeast of Wexford in McCandless Township Allegheny County.

Altitude of mouth of well, 1,094 feet above sea level.

	Thickness	From	To
Conemaugh			
Loam and clay,	17	0	17
Slate,	7	17	24
Sandrock,	6	24	30
Redrock,	13	30	43
Slate (horizon of Ames l. s.),	22	43	65
Redrock,	27	65	92
Slate, black,	94	92	186
Sand, green,	21	186	207
Sand, white,	89	207	296
Slate, white,	44	296	340
Sand (Dunkard?)	31	340	371
Slate,	26	371	397

WELL NO. 201—Continued.

Allegheny			
Sand, white,	43	397	440
Slate, black,	87	440	527
Coal,	4	527	531
Slate, black,	71	531	602
Sand, white,	21	602	623
Slate,	63	623	686
Pottsville			
Sand (Gas),	29	686	715
Slate,	33	715	748
Sand,	11	748	759
Slate.	16	759	775
Sixtyfoot sand (Salt sand?),	30	775	795
Pocono			
Slate (6¼ casing 801	40	795	835
(Big Injun),	95	835	930
Slate, } (Big Injun?)	7	930	937
Big Injun,	145	937	1,082
Slate, blue,	33	1,082	1,117
Little Injun,	110	1,117	1,227
Slate and shells,	229	1,227	1,456
Salt sand (full of water) (Murrysville),	111	1,456	1,567
Slate,	25	1,567	1,592
Hundredfoot,	17	1,592	1,609
Slate, } full of water,	6	1,609	1,615
Hundredfoot,	78	1,615	1,693
Slate and shells (4⅞ casing 1698),	60	1,693	1,753
Catskill			
Thirtyfoot	24	1,753	1,777
Slate,	33	1,777	1,810
Boulder,	27	1,810	1,837
Slate,	30	1,837	1,867
Sand,	8	1,867	1,875
Slate,	36	1,875	1,911
Sand (Gordon)	13	1,911	1,924
Slate,	43	1,924	1,967
Fourth sand,	18	1,967	1,985
Shale,	1	1,985	1,986

WELL NO. 382.

John Grazier No. 1. Located one-half mile south of Conway, Beaver County.

Altitude about 765.
Record furnished by George S. Reed.

	Thickness	From	To
Recent			
Sand,	12	0	12
Quicksand and gravel,	21	12	33
Allegeheny			
Bluish shell rock,	10	33	43
Fire clay, tough,	22	43	65
Shale, black,	35	65	100
Coal (Lower Kittanning?)	2	100	102
Fire clay and shale (slate)	58	102	160
White sand rock,	22	160	182
Shale,	161	182	343
Gray sand rock (Gas sand?)	28	343	371
Shale,	6	371	377
Shale,	13	377	390
Pottsville			
Hard sharp sand rock (with some gas),	12	390	402
Shale (Salt sand),	6	402	408
Sand rock, salt water (Salt sand?),	7	408	415
Shale (cased here),	3	415	418
Shale,	7	418	425
Sand rock,	13	425	438
Shale,	11	438	449

WELL NO. 382.—Continued.

		Thickness	From	To
Pocono				
Soft white sandstone; (salt water),		41	449	490
Hard sharp sandstone; gas,	(Big Injun?),	112	490	612
Soft shale,		23	612	625
Shell,		3	625	628
Shale,		22	628	650
Hard white sandstone,		27	650	677
Shale,		18	677	695
Sand rock; gas,		44	695	739
Soft shale,		111	739	850
Shale and shells,		45	850	895
Hard rock sandstone,		20	895	915
Shale,	(Murrysville, sand?),	30	915	945
Hard gray sandstone,		15	945	960
Shale with hard shells,		60	960	1,020
Gray shale,		50	1,020	1,070
Reddish shale,		45	1,070	1,115
Hard dark sandstone,	(Hundredfoot?),	17	1,115	1,132
Gray shale,		12	1,132	1,144
Pebbles with gas,		1	1,144	1,145
Gray shale,		15	1,145	1,160
Hundredfoot with gas,		27	1,160	1,187
Gray shale,		138	1,187	1,325
Catskill				
Hard shell,		2	1,325	1,327
Gray shale,		468	1,327	1,795
Red shale,		25	1,795	1,820
Chemung				
Gray shale,		85	1,820	1,905
Hard gray sandstone,		20	1,905	1,925
Gray shale,		670	1,925	2,595

A comparison of wells 201 and 382 will give some idea of the litologic change that takes place in the beds from east to west across the quadrangle.

UNCONFORMITIES.

During the deposition of the material under the sea which makes up the great thickness of sedimentary rocks shown in the above well sections, the sea bottom was many times slowly lifted and depressed by movements within the earth's crust. At the end of Pocono time, an uplift of such magnitude occurred that the ocean floor became dry land over a considerable area of what is now Pennsylvania, West Virginia, and Ohio. While thus exposed to erosion a considerable thickness of the Pocono rocks were disintegrated and returned to the sea by streams. After the lapse of a considerable period of geologic time, this land mass was again slowly submerged, and Pottsville sediments were deposited unconformably on the old Pocono land surface. Thus it can be easily seen that if by this movement the older rocks were tilted at a greater or less angle, they would not lie parallel to the newer beds above. Other unconformities of less magnitude occurring in these rocks will not be discussed in this paper.

STRUCTURE.

Since the deposition under the sea of the great thickness of sedimentary rocks described above, these strata, as a whole mass, have been many times slowly raised and depressed by movements within the earth's crust. This process has been such that in being lifted to their present height these strata have been warped and more or less wrinkled out of thir original approximately horizontal position. In this quadrangle and the region surrounding it, the wrinkling has been comparatively slight. The general tendency of the movement has been to tilt the whole mass to the south and southeast, and to create more or less distinct folds having a general northeast-southwest trend.

By structure is meant the shape or lay of the beds. In describing structure an upward-bending arch is called an anticline, and a downward-bending trough a syncline. The axis of a fold is that line which at every point occupies the highest part of an anticline, or the lowest part of a syncline.

METHOD OF PORTRAYING STRUCTURE.

Base map. The map on which is printed the geology of the oil and gas sands of the Sewickley quadrangle was made by the Topographic Branch of the United States Geological Survey on the scale of 1:62,500, or approximately 1 inch to 1 mile. On this base are shown all surface features of sufficient size to appear on the map, such as cities, towns, railroads, roads, trails, streams, hills, valleys, etc. These maps, printed in three colors, black, blue, and brown, are usually made in advance of the geologic work, but in the case of the Sewickley quadrangle the topographic and geologic work was done at the same time and to some extent in conjunction.

Object of structure maps. From the results of previous work of this nature it was thought best to make a structural map of the most prominent oil and gas-bearing sand with as much accuracy as the available data and the time to be devoted to the work would allow. This was done in order to find out to what extent the pools of oil and gas occurring in the bed conform to some system with reference to their structure, and, to further see if the structure of the oil-bearing bed resembled that of some outcropping stratum closely enough to justify the use of such a map of the outcropping bed, in undeveloped areas, in search for new production. Two maps are necessary because of the unconformity between the Pottsville and Pocono formations which may greatly disturb the parallelism of the two beds over comparatively small areas. This degree of convergence or divergence of the two beds is also effected from point to point by a variation in the rate of deposition of the intervening beds.

If an accurate map of the structure of an oil sand is of value in testing for oil and gas, the special point to be attained is a method by which this map can be made *before* and not after the expensive test of the drill. It is safe to say, from the above reasons, that it is impossible to make a perfect map of this nature. It is just as safe, however, to assert that under the average conditions found in a large portion of the Appalachian oil field it is possible to make a map of sufficient accuracy to be of very great value in locating favorable areas for oil and gas. The value of such a map is greatest where the test wells are sufficiently numerous to give a fair knowledge of the changes in the lithological character of sands, variation in distance between them and outcropping beds, and of the amount of salt water contained in them.

Necessary steps in mapping an underground bed. In many areas where direct measurements to an oil or gas sand to be mapped are too few to admit of the construction of a map of the desired accuracy from these data alone, it is sometimes possible to supplant it by using as a secondary horizon some prominent outcropping stratum, from which the distance to the underground bed at a number of places can be accurately obtained from well records. In areas where the nature of the outcropping rocks is such that no single horizon can be accurately traced over any large area, and where the distance to the underground bed from any surface horizon varies quite rapidly from place to place, it is not possible by any known means to make an accurate contour map of the underground bed. Hence the first important step in the prospective mapping of an underground bed cropping at no place on the surface is to determine what direct information may be had of this bed as to its extent, change in thickness, texture, and dip. The next step is to see if outcropping rocks furnish clearly defined horizons which may be traced over comparatively large areas, and whose distances from the underground bed may be determined at a number of places with a fair degree of accuracy. With these points settled the work of mapping the structure of the underground bed is simply one of collecting data for the construction of a detailed structural map of the surface rocks, and of revising this map by the introduction of direct measurements obtained upon the lower bed in such way as to change this map of the surface rocks so that it will represent the structure of the lower bed.

Structural map of outcropping rocks. For reasons given above, the Ames limestone was selected as a key rock upon which to make a structural map of the outcropping rocks. To determine the dip of this bed spirit-level lines were run to a large number of points along its outcrop, and at the same time elevations were secured, where possible, on all other outcropping beds having a determinable interval (within a small limit of error) above or below this key rock. These elevations were later reduced to equivalent ones of the Ames limestone at each point by adding or subtracting, as the case might be, the known interval, of the bed from the Ames. All elevations were then platted on the base map at their respective locations.

The next step in the construction of this map was to connect all points on the base map showing equal heights of the top of the Ames limestone above sea level by contour lines having a vertical interval of 10 feet. These lines then represent level lines drawn around the sides of the anticlines and synclines in that bed and, therefore, reveal its shape or structure.

It is obvious that the accuracy with which these contours are drawn depends directly upon the number and location of the elevations obtained. The most perfect map possible would be one made by actually running out with a transit the entire line of outcrop, not only of the Ames limestone, but also that of each associated bed, above and below, which is well marked over the area, and from which interval to the Ames limestone can be determined at all points within a small limit of error. Such a map, however, was without the province of this Survey, which can hope to depict the minor details of the structure only in a general way.

Plate V shows contours of the surface structure of the Ames limestone printed in green. On this map the crop line of the Ames limestone is also shown as a green line, which approximately follows the topographic contours.*

Points at which spirit-level elevations were taken along this crop line are located by crosses, and the height in feet above sea level shown by accompanying numbers in green. The doubtful elevations are questioned, as are all estimated elevations of the Ames limestone, which were taken from other beds.

Crop line of Ames limestone. On the map the crop line of the Ames is shown to be about half-way up the sides of the hills in the southern part of the quadrangle. Northward the rise of the rocks brings the outcrop of the Ames limestone higher and higher until at the southern border of Butler county it encircles only the higher ridges. Continuing northward the areas under lain by this bed grow smaller and smaller. Over this part of the quadrangle the structure of the Ames limestone can not be accurately drawn from crops of that bed alone. The exposures of other beds having known intervals from it are too meager to justify an attempt at mapping. The structure of a limited portion of these areas could be mapped fairly accurately by the combined use of several poorly exposed beds, using one of them as a secondary key rock, but the uses to which a general map on this scale is to be put did not, in the writer's opinion, justify the time and expense required to minutely examine the whole area for this data.

STRUCTURAL MAP OF HUNDREDFOOT SAND.

The Hunderfoot sand, which is one of the most prominent and prolific oil-bearing rocks of southwestern Pennsylvania, has been selected as the best horizon upon which to draw structural contours of the oil sands. This bed is always found in wells drilled to its

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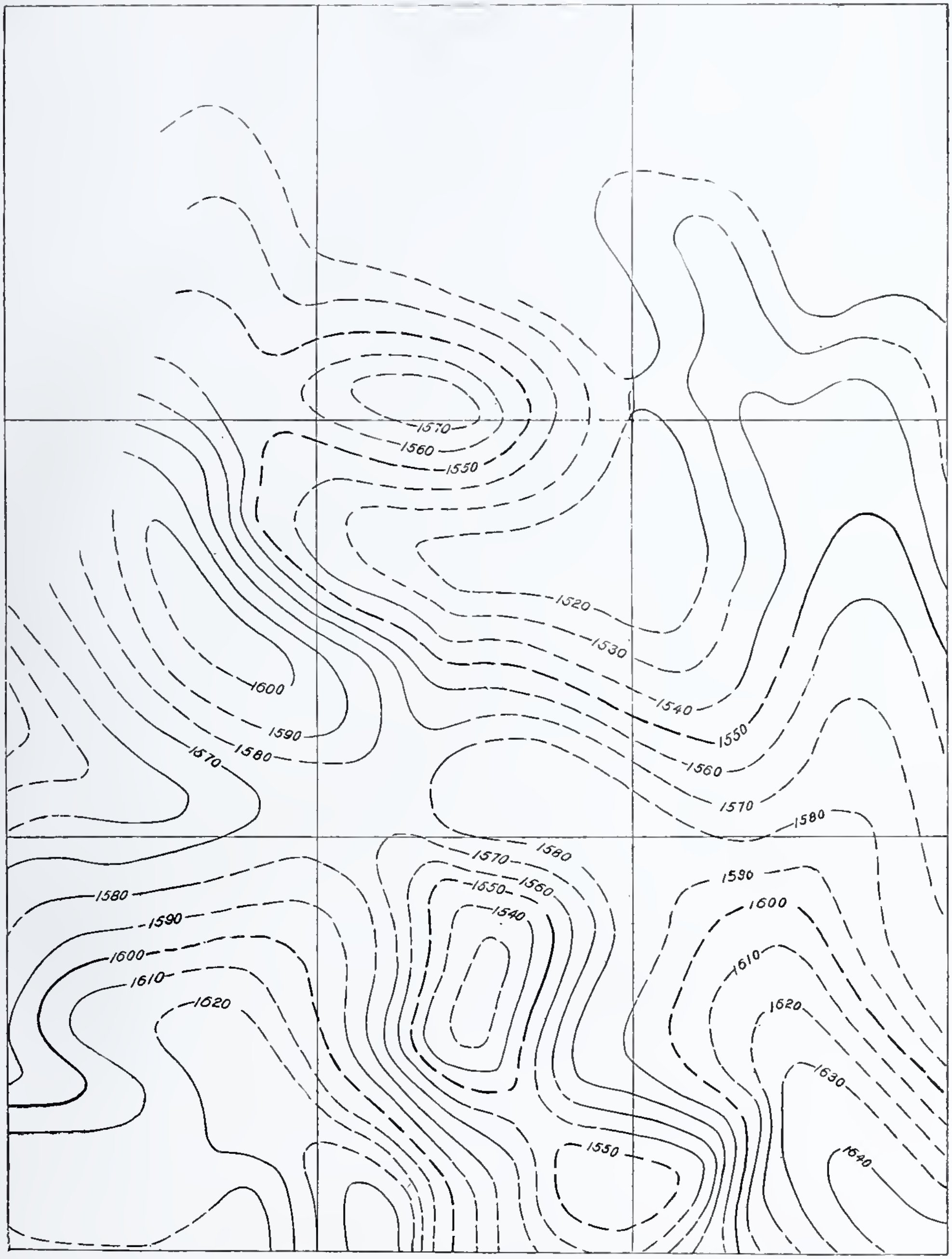
*Fine brown lines on the base, which show the shape and height above sea level of the surface of the earth.



CONVERGENCE SHEET SHOWING DISTANCE BETWEEN THE AMES LIMESTONE AND THE HUNDRED-FOOT SAND IN THE SEWICKLEY QUADRANGLE

Each line is supposed to pass through points on top of Ames limestone having a given distance above top of Hundred-foot sand. In areas left blank, the Ames limestone has been removed by erosion

horizon over the Sewickley quadrangle, and in this area it has produced more oil than all the other sands combined. For this reason measurements to the top of this sand are given in more records than for any other bed.

A large part of the field work required to make this map consisted in running spirit-level lines from well to well over the area in order to get the altitude of the top of the casing in each above sea level. while on the ground each well was plotted on a topographic base map, and the farm name, number and owner of well recorded, together with any other data that could be gathered regarding producing sands, salt water, conditions of pay, etc. Later owners of wells furnished records of many of them, in which, among other things, are given measurements from the top of the casing in each to the top of the Hundredfoot sand. These show that over the Sewickley quadrangle this sand lies below sea level. In order to avoid the confusion likely to arise from the use of minus elevations on the map, a datum plane 2,000 feet below sea level was chosen, all the contours being numbered according to distance in feet above this plane.

In areas producing from sands other than the Hundredfoot, where the well records show no measurements to that bed, the known interval of one or more of the producing sands was used to reduce these measurements to equivalent sands on the Hundredfoot. In places where no wells have been drilled, approximately correct elevations on the Hundred foot were in some instances secured by using the long interval from the Ames limestone to that bed, though most of such elevations can easily be in error as much as twice the contour interval, because of the rapid change in distance between the key rocks over small areas. In many instances the Ames can not be relied upon for details of structure of the oil sands, but elevations on it were used to get the trend of the principal articlines and synclines.

Convergence between the Ames limestone and the Hundredfoot sand. Plate VII shows the distance between the top of the Ames limestone and the top of the Hundredfoot sand by lines, each of which is supposed to be drawn through points of equal distance between these beds. These lines are therefore not contours representing the shape of a surface, but show the thickness of the rocks lying between the key horizons.

In previous work of this kind in southwestern Pennsylvania and eastern Ohio(a) the key rocks were found to lie so nearly parallel, and the variation in distance between them so uniform from point to point, that it was possible to make a drawing called a convergence sheet, which shows the distance from the surface bed to the key sand at all points on the map within a small limit of error. By the use of this drawing, elevations taken from the surface bed in areas where no wells were found and where no direct measurements to the key sand could be secured, were easily reduced to approximately correct elevations on the key sand. In this way the structural map of the Hundredfoot sand was strengthened in areas where no direct measurements could be had to this bed. Within the Sewickley quadrangle the rapid and irregular change in interval between the Ames limestone and the Hundredfoot sand, as well as the lack of sufficient data concerning this variation, prevented the making of a drawing of this kind.

(a) Bulletins Nos. 318 and 346, U. S. Geol. Survey.

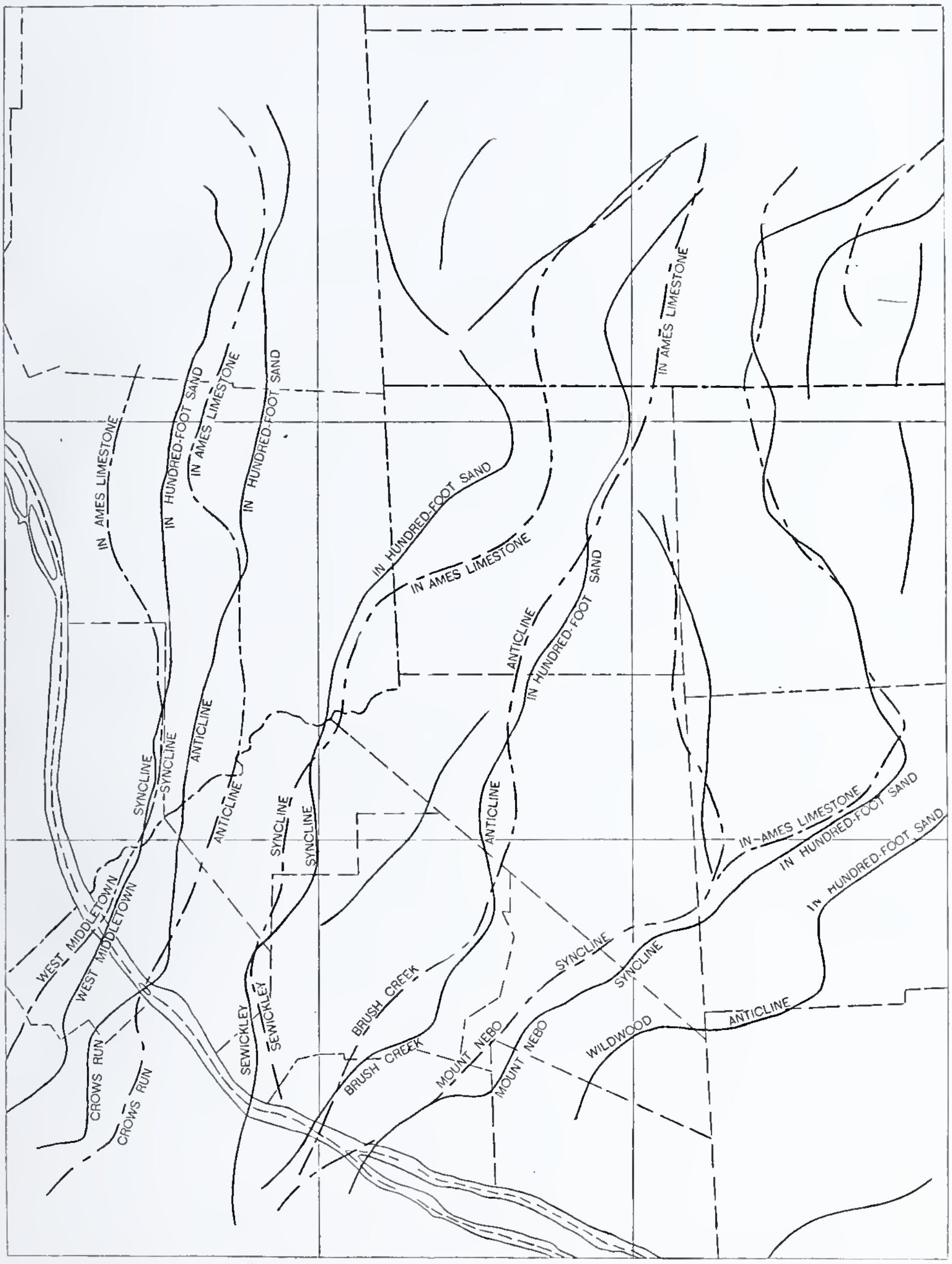
At first glance the great variation in interval between the key rocks might be thought to cause a correspondingly large one in the structure of each. By a comparison of Plates V and VI this is seen not to be true. The variation in the structure of the two key rocks, as shown by the structural contours, is an exaggeration of the true difference in structure, because of the uneven distribution of the points at which elevations were taken on each of these beds. If it had been possible to get elevations on both beds at exactly the same points, the variation of the structural contours would then have been due mainly to variations in interval between the beds plus the personal equation involved in the drawing of those contours.

Attention should also be called to the fact that the true variation in the structure of the Ames limestone and the Hundredfoot sand is one of difference in the magnitude of the folding rather than a variation in the direction and extent of those folds. A comparison of the maps will show at once that the surface beds are much flatter than those of the deeply buried beds.

Accuracy of structural maps. The accuracy of these maps at any point depends, of course, on the amount of correct data used at that point in their construction. This data varies materially from place to place, and the corresponding accuracy therefore changes rapidly within short horizontal distances. For the map of the Ames limestone the subject may be dismissed by stating that in areas where the numbers along the crop line are thickest in the Southern part of the sheet (plate V), the map is correct within a vertical distance of 5 feet. In those places of 1 or 2 miles square where no elevations are shown, the limestone may be found at certain points to be 20 or even 30 feet higher or lower than the contours show it. Between these extremes are all gradations of accuracy. The main structural features are doubtless correct within a comparatively small horizontal and vertical error.

What has been said of the accuracy of the structural map of the Ames limestone is, in a measure, true of that of the Hundredfoot sand, though the latter was intended to be done in more detail.

Inaccuracies in this map are largely due to the lack of records of wells to which levels have been run, and possibly in a few instances to mistakes made by drillers in locating the top of the Hundred foot



AXES OF FOLDS IN THE AMES LIMESTONE AND THE HUNDRED-FOOT SAND IN THE SEWICKLEY QUADRANGLE

These beds are about 1600 feet apart. The variation of the anticlines and synclines as shown on the map is probably exaggerated because of unequal distribution of data

(Anticlines are upward-bending arches, synclines are downward-bending troughs)

sand. In some cases drillers have called the first solid mass of sandstone struck at about the horizon of the Hundred foot the top of that bed. At other places other drillers have classed the slate and thick "shells" directly overlying this solid sandstone as part of that bed. In still other places drillers have confused the top of the Hundredfoot and the top of the Fiftyfoot, which is the lower member of the Hundredfoot. However, in most instances it has been possible to detect this source of error by a correlation of the drill records, and in so doing establish approximately the top of the Hundredfoot sand in those areas where only the Fiftyfoot is mentioned.

In nearly all cases where the records were not furnished they were either never kept by the driller, or were lost or thrown away when apparently of no further use to the owner. This lack of the detailed history of each well is the source of most of the errors, not only in the structural map, but also those that may be made in the interpretation of this data. It is safe to say that if the impossible had happened and every geologic fact noted and preserved during the time these wells were drilled, and these data were now available, the structure of the Hundredfoot sand could have been worked out with almost mathematical accuracy, and this together with the other data now lost, would have made easily possible a clear explanation of the whole process of oil and gas accumulation within this quadrangle.

PROMINENT STRUCTURAL FEATURES.

The axes of the anticlines and synclines over the Sewickley quadrangle are not straight lines, but follow long sinuous curves having a north-south, to northeast-southwest trend.

There are three well-defined anticlines and a corresponding number of synclines within the area. So far as is now known, but one of these, the West Middletown syncline, has heretofore been named.

West Middletown syncline. From a point about one mile west of Big Knob, New Sewickley township, Beaver county, where the northern extension of this syncline apparently dies out in a rapid rise of the rocks to the north and northwest, it has been traced southward as a continuous trough to a point in Independence township, Washington county, about a mile south of Dunsfort, which is at the western edge of the mapped area.

The bottom of this syncline is not flat, nor is the pitch of its axis uniformly to the south, but throughout the whole length of the portion which has been mapped it is broken up by cross folds into a chain of canoe-shaped basins. These basins are more or less cut off from each other, though at no point is the continuity of the trough completely broken. Southward the basins grow deeper and deeper, with the pitch of the axis of the trough becoming more abrupt on the north side of each succeeding basin.

Within the Sewickley quadrangle the lowest point along the axis of this trough is where it cuts the western border about 1½ miles from the southwest corner. Here the trough on the Hundredfoot sand is more clearly defined than the one on the Ames limestone, which apparently is about half a mile farther to the west.

From this point northward the bottoms of both troughs rise slowly; the axis of this fold in the Hundred foot lies a short distance west of Leetsdale, and within two hundred yards of the old Economy distillery. From here the axis has a due north trend, and rises at the rate of 30 to 40 feet to the mile.

The trough in the Ames limestone is very flat and irregular. In running spirit level lines over the roads along the course of this fold few outcrops of the Ames were seen, and the generalized trough in the Ames, shown in plate V, is probably not very accurate, though the main features are essentially so. By an examination of plate VIII, it will be seen that over most of Economy and the southern portion of New Sewickley township structure lines on these two beds vary greatly. A portion of this difference is due to lack of sufficient data on the Ames limestone.

Crows Run Anticline. The arch which lies to the east of the West Middletown syncline has been called the Crows Run anticline, from the name of the largest oil pool through which its axis passes. In the Hundredfoot sand this axis lies roughly parallel to that of the West Middletown syncline, at a distance of less than one mile through the southern half of the quadrangle, and farther north not more than 1½ miles apart. By an examination of plate VIII it will be seen that the axis of this anticline in the Ames limestone lies practically parallel with and almost above that of the Hundredfoot. In the center of Economy township the axes of the arch in these beds cross; that in the Ames limestone apparently curves sharply to the northwest for a short distance, from which point northward the two axes parallel each other, but gradually converge until they are again almost superimposed in the northern part of the Crows Run oil field. The evidence favoring this wide variation in the axis of the Crows Run anticline in the Ames is by no means conclusive, though while in the field it was thought that enough data had been collected to clearly settle this point. There is a strong possibility that this arch in the Ames limestone continues practically parallel with that in the Hundredfoot sand throughout its whole course.

Sewickley syncline. Eastward from the crest of the Crows Run anticline the rocks dip to the trough of the Sewickley syncline, which is one of the most prominent and clearly defined structural features of the quadrangle. The axis of this fold crosses the southern boundary of the quadrangle about 1½ miles southeast of Coraopolis, passes northward through the town of Sewickley, thence one-half mile east of Sevins oil pool, crossing Big Sewickley Creek about one mile west of Duff City, thence in a big bow northeastward to a point one mile west of Thornhill, where it curves sharply to the northwest to a point about one mile west and a little north of Criders Corners. At this point the syncline apparently breaks up into two minor troughs, one keeping the general northwest trend, but gradually bending northward to where it crosses Brush Creek about half a mile east of Oak Grove church. From this point northward its course can not be traced, through lack of good surface exposures, and of records of oil wells drilled in that area. The other branch of this syncline has a northeast trend, the trough rising rapidly until it dies out against the side of the Brush Creek anticline about one mile southwest of Callery.

Brush Creek anticline. This anticline, which is the most prominent fold on the quadrangle, lies east of the Sewickley syncline. In the Hundredfoot sand the crest of this arch passes half a mile west of Callery about the same distance west of Hendersonville, midway between Thorne Hill and Brush Creek, half a mile east of Duff City through the Grubbs oil field, and from this point pitches very rapidly southward to the Ohio river about half a mile east of Dam No. 3 at Coraopolis. Southward from here the axis continues to pitch until the fold disappears near the junction of the Sewickley and the Mt. Nebo syncline, the next important fold to the east.

Mt. Nebo syncline. This trough apparently branches off to the east from the Sewickley syncline, a short distance off the quadrangle to the south of Coraopolis. From this point it has a northeast trend, passing to the east of the Brush Creek anticline. It crosses the Ohio river at the west end of Neville Island, and from this point to Mt. Nebo oil field, through which it passes, the axis of the trough rises at the rate of 60 or 70 feet to the mile. From less than a mile northeast of Mt. Nebo church the trough pitches slightly to the bottom of a shallow basin about two miles southeast of Ingomar. From this basin the trough rises slowly, passing half a mile south of Keown, to a point about one mile west of where Pine Creek leaves the quadrangle to the east. From this point the syncline apparently bends abruptly westward until the trend is a little west of north, though this may possibly be a minor branch of the main trough of the syncline which may continue its northeast trend. Conclusive data on this point is not at hand. This trough passes one and a half miles east of Brush Creek, where it rises at a rate of 40 to 60 feet to the mile. The Mars oil pool lies less than a mile to the east of this syncline, at which point it is narrow and quite shallow. Northward the data seem to show that this trough bends again to the northeast, and leaves the eastern border of the quadrangle about 2 miles from the northeast corner, though this is by no means certain.

By an examination of plate VIII, it will be seen that the Sewickley syncline, Brush Creek anticline, and the Mt. Nebo syncline, in the Ames limestone conform quite closely to those just described for the Hundredfoot sand. As stated before, this map probably shows a greater degree of variation than actually exists.

Wildwood anticline. The axis of this anticline, which lies to the east of the Mt. Nebo syncline, enters the quadrangle from the east, about half a mile south of Pine Creek. Tracing this fold southward it is found to have a southwest trend, being roughly parallel to the Mt. Nebo trough and usually less than 1½ miles from the axis of that fold. It passes half a mile to the east of the Sandle oil pool, and apparently separates this pool from the Wildwood pool which lies along the eastern side of the arch. This anticline crosses the Plank Road less than a mile north of Perryville, at which point it swings sharply to the west, passing near the southwest corner of Franklin township. Between these points it forms the crest of a low dome from which the axis pitches very rapidly to the Ohio river in the vicinity of Glenfield; beyond that point the anticline becomes more and more obscure. From the western end of the above mentioned dome a prominent minor anticline pitches off to the south, and crosses the Ohio in the vicinity of Avalon, and at the eastern end of this dome another anticlinal nose projects out to the southeast, passing a mile or more to the east of Westview.

To the southeast of the Wildwood anticline the trough of a syncline cuts across the corner of the quadrangle, a mile or so to the southeast of Bellevue. This is a part of the Nineveh syncline, which is the principal structural feature on the Carnegie quadrangle, to the south of the Sewickley, though the main axis of this syncline probably passes farther to the southeast.

OIL AND GAS POOLS ON THE SEWICKLEY QUADRANGLE.

INTRODUCTION.

Of the 227 square miles embraced by the Sewickley quadrangle, about 25 of these have produced oil with more or less gas, and about 12 additional square miles have furnished gas alone. This territory is divided into more than ninety separate pools, varying in size from a few acres to several square miles.

Most of the oil has come from the Hundredfoot sand, in which over fifty pools have been discovered. Other sands producing oil are the Gordon, Snee, Boulder, Fourth, Fifth, and Thirtyfoot. The gas comes principally from the Fourth sand, though pools of greater or less extent are found in all the sands named above.

Nearly all the oil and gas pools on this quadrangle have been pretty thoroughly tested, and the production of each has long since reached its maximum, from which each year it is gradually becoming less and less as the pools approach exhaustion. Without the producing areas test wells are numerous and are so located that it is safe to say that no very large pools remain undiscovered, and probably very few smaller ones. Most if not all the oil pools yet to be developed will probably be found as small extensions to pools already drilled. In the following discussion the more favorable points at which such extensions may be found will be pointed out, but in doing so the author wishes to again emphasize the statement that the favorable locations could have been named with a far greater certainty if producers had only taken the trouble to preserve a full account of facts learned in drilling the wells on this territory. The difficulty of making detailed predictions on incomplete data may be better understood when it is said that the failure of a single record to show that a certain sand in a given well was dry, had salt water, or a show of oil or gas, frequently bars the geologist from making a definite statement, because those very details furnish the strong bits of evidence upon which he must base his conclusions. Unfortunately the geologist can not foretell in the field where this knowledge is lacking, because the problem is not evident until the well records are collected and examined, and the structure of the sands worked out. The intricate problem of oil and gas accumulation is not yet thoroughly understood. The factors involved in these accumulations vary greatly in importance from place to place. In fact it is entirely possible for pools of oil to occur in one region by processes entirely different from those in another. The fallacy of attempting to provide a set rule for the occurrence of oil and gas with reference to the structure of the oil sands, is too evident to justify discussion. Only by a most intimate knowledge of the geologic conditions of a given region can the geologist expect with confidence to materially assist the producer in finding new pools.

Two sets of numbers have been used in referring from the text to plate VI. The large numbers on this plate refer to corresponding numbers in the appendix, where short descriptions are given of bench marks established when spirit level lines were run over the roads of the quadrangle for vertical control. The smaller numbers attached to well symbols refer to wells discussed in the text and also to a tabulated list of abbreviated well records published in the appendix.

By referring to this list may be found the elevation of all the numbered wells to which levels were run. Aside from these numbered wells, the elevation above sea level of nearly all the other wells shown on plate VI were secured by spirit level. It is to be regretted that much of value that might have been acquired from closer study of the oil pools of this quadrangle is lost through the lack of records of a large number of these wells, and the incompleteness of those that have been preserved and so generously furnished by producers through out this territory.

MOON TOWNSHIP, ALLEGHENY COUNTY.

A part of this township is included in the southwest corner of the quadrangle. This portion embraces parts of the Coraopolis and Moon oil pools, and a considerable gas area in the Fourth sand to the east and north of Carnot.

Moon oil pool. This pool extends over about one-fourth of a square mile in the extreme southwest corner of the quadrangle, most of it being in the quadrangles to the west, southwest, and south. The oil comes from the Gordon sand, which here also shows considerable salt water in some of the wells. In the P. H. Stevenson No. 1 (map No. 1) from eight to ten times as much salt water as oil is pumped. The Samuel Stevenson, (2) located a short distance southeast of the first named well, pumps a much less ratio of salt water, while the John Stevenson (3), located in an orchard a short distance west of the village of Moon, pumps less than one-fourth as much water as oil. It appears to be the rule here that an increase in water in a well results in a decrease in the production of oil. The initial productions of the wells of this pool are not known, but it is said that many of them made over 100 barrels per day. The field is an old one and the wells are about exhausted. No drilling is now being done, and only a few incomplete records of wells could be secured.

The Gordon sand is quite thin in this pool; the records at hand show it to range from 7 to 19 feet. A short distance farther to the northwest from this pool the Gordon is said to pinch out entirely. With this in mind it is a little strange that well No. 1 should pump so much more water than No. 3, since the former is located at a point where the Gordon sand is about 10 feet higher than it is at No. 3.

The most eastern extension of this pool is on the Lewis Hood and G. G. Gordon farms. In No. 1 Gordon (map No. 4), the Gordon sand is 12 feet thick, with oil in the top of the sand, no mention being made of water. The Moon pool has been entirely encircled by a string of unproductive wells. In one of these wells on the Hood farm (No. 5) a short distance south of No. 4, a strong flow of fresh water was struck at a depth of about 40 feet, in what is probably the Connellsville sandstone. This water was pumped at the rate of 90 barrels per hour without materially lowering the head in the well. At the time of the writer's visit it was still flowing copiously.

Coraopolis oil pool. This pool extends from the Ohio river at Coraopolis, southwest to within less than a mile of the eastern edge of the Moon field. It was opened up in 1890-93, nearly all the oil coming from the Gordon sand, which has furnished a number of wells at the rate of two to three hundred barrels per day. This sand is seldom more than 15 feet thick. The best part of the pool was probably on the E. Cassidy, Kerr heirs, Martha Getty, and the S. B. Neeley farms, though a number of good wells were struck on adjoining farms.

It will be seen from plate VI that southwest from Coraopolis this pool lies along the flank and crest of the Brush Creek anticline which pitches rapidly in that direction until it disappears in the trough of the Sewickley syncline. This syncline as a narrow, shallow trough which crosses the center of the field from north to south. Southwest from this point the oil has accumulated along the flank of the Crows Run anticline. From the map it will be seen that the lower endge of this pool lies practically on a level along the 1330 foot contour, while the upper edge varies between the 1,360 and 1,380 contours. The structural position of this pool indicates that it has accumulated at the top of a saturated portion of the Gordon sand. Records of wells within this pool seldom show more than the depth to the top and the bottom of the Gordon sand, but from data collected in the field, salt water seems to have sooner or later made its appearance in each of the wells along the southeast margin of the pool, and that this water is gradually increasing as the wells decrease in the production of oil. In several instances marginal wells have been completely flooded by salt water. In such cases a well usually shows a rapid increase in oil for a few weeks or months, and then suddenly begins pumping salt water exclusively. This seems to show that the water moves as a body up the slope of the bed.

One of the most difficult geologic problems connected with a study of accumulations of oil and gas is that of providing a logical explanation of the origin and behavior of these bodies of salt water in the oil sands. In the instance just cited, it would naturally be suposed that this water is static, and that it saturates the whole bed below the oil pool up to some definite level. This is not true, since only two or three miles farther south on the Carnegie quadrangle, and down the continuous dip of the bed, the Gordon sand has been reached in a large number of wells, where it is almost universally considered dry by drillers. It is to be regretted that more data is not available regarding this phenomenon.

In many of the wells throughout the Coraopolis oil pool the Fourth sand produces gas. In well No. 16 on the E. Cassidy farm, a strong flow of gas was found in this sand. Northwest from the Coraopolis oil pool and in the vicinity of Carnot, the Fourth sand has furnished an immense quantity of gas. The S. C. Dally (19), the Thomas Sterling (18), L. T. Arnesburg (23), and wells on the Vandevort and J. J. Miller farms have furnished most of this production. The initial closed pressure of these wells is not known, but it is said to have been great. The wells are now nearly exhausted, and in some of them sufficient salt water has appeared to require pumping. No evidence is at hand to show conclusively that this is Fourth sand water; it probably comes from some of the upper sands.

Throughout this township the Hundredfoot sand appears to carry more or less salt water, with now and then a show of oil. In the E. Worth well (32) a pocket of gas was found in the Gordon sand, and a good gas well in the Fourth sand. The writer was informed by Mr. Worth that the well flowed salt water from the Hundredfoot sand. A large volume of salt water was also encountered in well No. 25, which according to Mr. D. O. Vandevort, owner of the farm, was of sufficient pressure to offer unusual difficulties in plugging, the water not being shut off in time to prevent its spoiling a water well 200 feet deep and 150 yards away. In the Arnesburg well (22) there was water and a show of oil. After thirty days' pumping the water and oil were both exhausted. In the Dally well (19) it is said that several barrels of oil were bailed from the Hundredfoot sand; below the "break," however, this bed was heavily charged with salt water. A good show of oil is also said to have been found in well 26, though no record of this well could be obtained. The Alexander Stevenson (29), is said to have been a dry hole, so far as oil and gas is concerned, but that term as applied by drillers has no reference to salt water. Half a mile west of this well No. 30 is reported as a good gas well in the Fourth sand. Less than a mile northwest of No. 30 and just off the western border of the quadrangle the Eliza McBride No. 1 well produced some gas. A quarter of a mile farther north the Thomas Pennell well found no oil or gas in the Hundredfoot, but made a fine flow of gas from the Gordon sand, for a day or so, but soon blew out. The Gordon sand is shown by the record to be 29 feet thick in this well. No mention is made of water in any of the sands, though the Hundredfoot probably carries more or less. A mile north of this well one on the William Sheets farm (31), found the Hundredfoot thirty feet thick, with no oil or gas. Three-fourths of a mile east of this point a well on the William Purdy farm (27), is said to have had a fine show of oil in the Hundredfoot sand. Half a mile southeast of No. 27 a well was drilled many years ago on the Scott farm (28), which is said to have had salt water in the Hundredfoot and some gas in the Fourth sand. By diligent inquiry while in the field the writer was unable to learn of any other wells within the area embraced by the circuit of wells mentioned above. If this is true the best place to test for a new pool in the Hundredfoot sand in the portion of Moon township within the Sewickley quadrangle is on the western edge of the crest of the low dome a little over three-quarters of a mile due south of well No. 27. If the Hundredfoot sand has a good pay in this area there is a fair chance of getting several small wells here in the Hundredfoot. As previously stated, this is not an especially favorable place for a pool in any sand, but it offers the best chance now remaining in this part of the township.

Judging from structure alone, there still appears to be a small chance of a little more oil being found by a slight extension of the Coraopolis pool in the Gordon sand with a location about 600 feet northeast of No. 7, on the Neeley heirs farm (8), and on the road, near the top of the hill east of the J. B. Watt coal bank. If a test here should be successful, another location due east, and another due north will probably cover the productive territory. If by any chance these are both successful, the territory should be cautiously extended true north from the first location. There are no other areas within the township that appear to warrant tests being made.

CRESCENT TOWNSHIP, ALLEGHENY COUNTY.

Crescent township has produced a considerable quantity of oil from the Hundredfoot sand in those parts of the Leetsdale and Shannopin pools that lie within its border.

In the Leetsdale pool south of the Ohio river most of the development work was done from 1900 to 1902. The wells were not very large, and apparently as a rule ran down rapidly in production. The Hundredfoot in this pool is from 25 to 40 or 50 feet thick. It frequently carries two pay streaks, one near the top and another near the middle of the bed, the latter furnishing the greater portion of the oil. The Hundredfoot carries more or less salt water throughout the pool. In well (36) seven times as much water as oil is pumped.

The Fourth sand has furnished some good gas wells in this area The Gordon sand seems to pinch out between wells No. 35 and 36.

Shannopin oil pool. Only a few wells in the vicinity of Wireton are in Crescent township. These produce from the Hundredfoot sand, which also carries salt water. Most of the development in this part of the pool was done in 1895-96. The records at hand of these wells are very incomplete and but little was learned in the field regarding the initial production of them. The pool is now about exhausted, many of the wells being abandoned.

There is little chance that other pools of oil will be found in this township, as the area seems to have been fairly well tested. From the limited data in hand it appears that a well located half-way between wells Nos. 31 and 41 would have the best show for new production in all the sands above and including the Fourth. This is a long chance, however, and it is possible that holes have been put down in this area of which the author has no account.

LEET TOWNSHIP, ALLEGHENY COUNTY.

Leet township lies north of Crescent and Moon townships.

Leetsdale oil pool. The Leetsdale oil pool is the only productive area of importance within the township. This pool occupies less than 160 acres in the Ohio River Valley at Leetsdale. The oil comes entirely from the Hundredfoot sand. As stated above, this sand also produces more or less salt water with the oil. In this connection it is also well to note that in this pool the ratio of salt water to oil in the wells seems to vary considerably, with changes in thickness and porosity of the pay. The thicker and more open portions of the pay streak generally furnish a greater ratio of water to oil. On the other hand, the amount of oil produced by a well is usually in direct ratio to the amount of salt water it pumps. As a rule the best wells are those that produce the most water, and when the water is exhausted in a well the flow of oil ceases. This rule holds good for all the oil pools found in the Hundredfoot sand throughout the Sewickley quadrangle. As has already been mentioned of the Coraopolis pool, water in the Gordon sand has exactly the opposite effect on the production of oil.

From the map (Plate VI) it will be noted that the Leetsdale oil pool is situated on the crest and western slope of the Crows Run anticline, at a point where the axis of this fold pitches quite rapidly to the south. In this pool the greatest difference in elevation of the oil sand is 33 feet, between wells 47 and 43. Strange as it may seem; the lower well (43), Mrs. A. A. Porter No. 1, is shown by the record to be a gas well in the Hundredfoot sand at a depth of 1,322, most of the gas being found 14 feet in the sand. In an attempt to verify this record the writer has been informed that it was later drilled to the Fourth sand, which doubtless furnished most of the gas. It is barely possible that this record applies to another well on the A. A. Porter farm. If such is the case, the fact still remains that the well is located at a point in the sand which is lower than either the Leetsdale or the Shannopin oil pools.

From a study of the detailed sections of the Ezra P. Young well (45) and the Taylor well (51) as shown on Plate III, a fair knowledge may be had of the rocks of this vicinity down to and including the Fifth sand.

Phillips oil pool. This pool consists of only two wells (49 and 50), both of which pump about 5 or 6 barrels per day from the Hundredfoot sand. These wells have been encircled by a line of dry holes only a few hundred feet away, in which the Hundredfoot was found to be hard and close with no water or oil. These wells pump salt water with the oil, and are apparently down to a settled production. Their records do not show the thickness of the pay streak, but from what is known of the Hunderdfoot sand in this vicinity, it is probably not over five or six feet. With the limited data in hand it is difficult to account for this supply of oil and water.

In the four gas wells situated to the west and northwest of 49 and 50, the production comes from the Fourth sand, which in well No. 51 is only seven feet thick. The Gordon is here reported one foot in thickness, but this may be an error, as a sandstone bed of that thickness might as easily belong to another horizon.

Prospective oil and gas territory in Leet township. In this township there appear to be several untested tracts of land of sufficient size to cover considerable pools of oil and gas, but in this vicinity the open, porous, conglomeratic lenses in the Hundredfoot sand which forms the pay streak, are very scare. In those areas where a good pay has been found, it has nearly always yielded more or less oil. The same may be said of gas pools in the Fourth sand. There is no geological aid to the location of these patches of porous rock; their position can only be determined by the drill. If the oil sand were of fairly uniform texture throughout the township, the most favorable places for oil in the Hundredfoot would be along the 1,420-foot contour on both sides of the Crows Run anticline north from the Leetsdale pool, and on the eastern flank of the Sewickley syncline in the extreme northeast corner of the township. Considering the extreme variability in the pay streaks of the Hundredfoot over this area, it is doubtful if local structure has played a very important part in the accumulation of these pools.

SEWICKLEY TOWNSHIP, ALLEGHENY COUNTY.

Sewickley township lies north of Leet, and borders Beaver county on the northwest. Within this township little oil and gas have yet been found.

Sevins oil pool. This pool is situated in the extreme southern portion of the township on Little Sewickley Creek. About fifteen wells have been drilled in this vicinity, six of which were productive. All of the oil comes from the Hundredfoot sand, which also carries salt water. This sand here varies from 24 to 30 feet in thickness. In well (62) 25 feet of good soft sand was found with a light production of oil and little salt water. In this well a show of oil is said to have been found in the Boulder sand. The pay in the Hundredfoot sand is very unreliable in this vicinity; the unproductive wells show the entire thickness of this sand to be hard and close. The ratio of salt water pumped with the oil seems to be less in this pool than that found in the Leetsdale pool. Half a mile east of this pool in Sewickley Heights township a group of four wells was drilled on the old Dairy Farm in an attempt to make an extension of the Sevin pool in that direction, but only a show of oil was found in one or two wells. The only hope for an extension in this pool is a little east of south from Sevins No. 11 (60), but any extension is dependent more on the location of a very erratic pay streak than upon structural conditions.

Aside from the Sevins pool, but two other wells within Sewickley township have found oil. These are two flowing wells (64) and (65) on the George Sohn farm in the extreme northern portion of the township. No records of these wells could be found, but they probably get their oil from the Boulder sand, which has a number of flowing wells a little farther to the north in the Craig oil pool.

Between the Sohn farm and the Sevins pool little drilling appears to have been done. A well (63) on the old Dairy Farm is said to have found some gas in the Hundredfoot sand. Three or four unproductive holes within this township on Sewickley Creek which have tested an area east of the Davis pool in Beaver county, and a well (66) in the extreme northeast corner of the township on the Prophater farm are all that could be located by careful inquiry over the township. It is believed that few, if any, others have been drilled.

In this area predictions regarding the location of new pools from a study of structural conditions, are of little value, because of the uncertainty of getting good porous sands.

If the Boulder and Hundredfoot sands had continuous pay streaks over this township, both of these should be found productive for a mile south of well 65, and a small pool in the Hundredfoot might be found less than half a mile northwest of well 63. These locations have a slight advantage over the remaining untested area, but the occurrence of new pools here depends upon conditions which the geologist can not foresee.

SEWICKLEY HEIGHTS TOWNSHIP, ALLEGHENY COUNTY.

Sewickley Heights township lies southeast of Sewickley and east of Leet. The Grubbs oil pool near the eastern edge of the township has produced a considerable amount of oil from what is said to be the Boulder sand, and some from the Hundredfoot. A small portion of the Glenfield pool is included in an angle of this township to the southeast. Nearly all of the oil in this pool comes from the Fourth sand, though the Third is oil-bearing in a few wells. Little or no oil has been found at other points within the township.

Grubbs oil fields. As may be seen from (plate VI) this oil pool is situated squarely on the flat crest of the Brush Creek anticline. From this pool southeast, the rocks dip quite rapidly to the trough of the Mt. Nebo syncline just east of Stonedale. From the structural position of this pool it has the appearance of being in a sand saturated with water.

According to the Anticlinal Theory as it is now generally accepted, pools of oil on anticlines have accumulated there through difference in specific gravity of oil and water, by which the oil, being lighter, rises along the slope of the porous bed until it reaches a point where the dip is arrested or reversed. In the Grubbs field, however, the records of wells mention no water in the Boulder sand. This is verified by both producers and pumpers, who are a unit in the statement that little, if any, water comes from this sand.

From all available data it seems that this pool occupies a lens of open porous sand which pinches out around the edges of the pool into a closer harder rock, and that the extent of the pool in every direction is limited to this pay streak. It is difficult to see how this oil could have been accumulated in the way mentioned above.

In this pool the John Wilson well (72) pumped several years from the Boulder, and later produced considerable oil from the Hundredfoot, which here carries some salt water. Other wells in this field have also found some oil in the Hundredfoot. This sand here ranges from 80 to about 100 feet in thickness, showing a remarkable thickening towards the east from Sewickley township, where it is seldom over 30 feet. What is called the Boulder sand in this pool is from 25 to 35 feet thick. This tendency to thin out toward the northwest is common to all the sands below the Big Injun.

Incidentally the fact should be pointed out that a number of unnecessary holes have been drilled in the development of this pool. In this instance probably not less than $20,000 has been absolutely wasted by rival companies in drilling wells only a few feet apart along the edges of adjoining leases. Such action seems more surprising when it is considered that this work was sanctioned by experienced oil operators, who are conceded to be fine business men. Here is evidenced the peculiar business ethics which have been practiced more or less in every oil field yet developed. Men who are otherwise honest and straightforward in their business methods, do not hesitate to locate wells on their leases with the unquestioned object of drawing through them oil from the sand under adjoining leases. This form of stealing so long sanctioned by custom, has been not only the source of endless wrangling and bitterness among producers, but it has also led to the wasting of millions of dollars in the sinking of useless holes

Since the Glenfield oil pool lies within three townships with the major portion in Aleppo township, this pool will be discussed as a whole under that township.

Northwest of the Grubbs oil pool, the Dusold well No. 71 is said to have been unproductive in both the Boulder and Hundredfoot sands, but to have developed sufficient gas in some lower sand to justify being attached to the pipe line for a year or more. No record of this well has been preserved. The William Knoder well (70) is said to produce gas from the Fourth sand which is here about 10 feet thick. The record of this well gives the Hundredfoot sand a thickness of 105 feet, and that of the Third 20 feet. It is barely possible that the Boulder and Third sands are confused in this well, and that what is called the Third here is really the Grubbs or Boulder sand of the Grubbs oil pool. In fact a careful study of the well sections as previously pointed out shows the difficulty of correlating by well records the Third, Boulder, and Snee as separate and distinct sands, and it is quite possible that they are not continuous beds over any very extensive areas. On the other hand the available data suggests that these are really members of one large sandstone, each of which has a tendency to merge into the other. From a study of these data it seems possible that the Boulder sand of the Grubbs pool, and that which is reported in the wells farther to the northwest, is in reality the Third sand member of this group, as mentioned elsewhere in this paper. No records of wells Nos. 67, 68, 56, and 97 could be secured, but it is said that these found their gas in the Fourth sand. vey, and Baker wells (55) in the borough of Sewickley, but they are said to produce more or less gas from the Fourth sand. It should be noted that the W. P. Snyder well (91) had a show of oil with salt water in the Hundredfoot, and some gas in the Fourth, though it was practically a dry hole. A careful record of this well furnished the writer by F. S. Crease, of Stonedale, who drilled the well, is shown plotted to scale in Plate II, and is published in full on page 42.

Probable location of new pools in Sewickley Heights township. The wells indicated on the map, Plate VI, are doubtless not all that have been drilled within this township, most of the land having of late years been purchased by wealthy Pittsburg people for country homes. In the course of the improvement work which followed, all evidence of the existence of old holes has probably in a number of cases been obliterated. To make the necessary inquiries and to search out the locations of these wells, required more time than it was thought advisable to expend on this phase of the work, as experience has shown that the chances of securing records of such wells are small. With the evidence in hand, however, it seems probable that a well located somewhere within a mile either north or northwest of well No. 56, on the W. P. Snyder estate, would get oil in the Hundredfoot, and possibly in the Boulder sand, with more or less gas in the Third and Fourth. This prediction is based on the assumption that these sands have good pay streaks over that area, which is probably not absolutely true. From Plate IX it will be seen that the Fourth sand pinches out in this vicinity. In such a case the chances are that gas will be found in any open porous part of this bed, near the northwestern edge, without particular reference to anticlines.

A small pool of oil in the Third sand might also be found in the vicinity of bench mark No. 31, Plate VI, though as in all other predictions the unknown quality of the oil sand must be taken into consideration. A well drilled three-quarters of a mile due west of No. 71 would stand a fair show of getting oil in the Boulder and Hundredfoot sands, and a less chance of gas in the Fourth. A hole put down one-quarter of a mile due north of well No. 90 might find a small patch of pay sand. A well the same distance northeast of No. 90 might also get oil in Boulder, Third, and Hundredfoot, though none of these chances are very good.

OHIO TOWNSHIP, ALLEGHENY COUNTY.

This township lies north of Kilbuck and east of Sewickley Heights. It has been well tested for oil and gas, resulting in the development of a considerable pool of oil in the vicinity of Mt. Nebo church.

Mt. Nebo oil pool. This pool was discovered and opened up in 1885-86. The first wells were of sufficient size to create considerable excitement among producers, but the pool failed to justify expectations. It is now producing a small amount of oil from about fifteen wells, the entire production being from what is thought to be the Third sand.

This pool lies squarely across the steep narrow trough of the Mount Nebo syncline in such a wey as to discredit local structure as an important factor of accumulation in this sand. The oil-bearing sand here has a maximum thickness of less than 30 feet, while the soft, conglomeratic pay streak is rarely, if ever, 10 feet in thickness. Little or no water is found in this sand. The Hundredfoot in this pool probably is water-bearing, though no mention is made of it in the well records, except in the John Hohman well (81), in which water occurred at two horizons in this sand. Throughout the township more or less water is found in the salt, Big Injun and Butler Gas (salt) sands, though in a few wells one or more of these is sometimes found to be dry.

The gas wells to the west, south and southeast of the Mt. Nebo pool probably get most of their gas from the Fourth sand. No records of wells 83, 84, 85, 86, and 88 could be obtained. In Crawford No. 1 well (87) a 4-foot pebbly pay in the Hundredfoot sand 10 feet from the top carried some gas, and a second pay 8 feet thick 54 feet below the first and 15 feet from the bottom of the sand showed both oil and gas. This well also produces some gas from the Fourth sand which is here 26 feet thick, with an 11-foot pay. In the Sebastian Weiss well (89) the Third and Fifth sands appear to be the gas producers. The Joseph Cookson well (82) carries water in the Hundredfoot, a show of oil in the Third, with no water, and gas in what the writer thinks may be the Fourth sand, though it is mentioned as the Fifth in the record. This sand is 71 feet below the top of the Third sand and 394 feet below the top of the Hundredfoot, as shown by the record of this well.

Ohio township seems to have been carefully prospected for both oil and gas. It contains untested areas of sufficient size to furnish only pools of small extent. It is possible that one of these spots may be found in the extreme southeast corner of the township half a mile east of well No. 88. Here the Hundredfoot and Boulder will probably have the best show for oil, and gas may be expected in all of the sands below the Boulder that carry a good pay streak. If a pool be found here developments should be north and south along the strike of the rocks. Oil in the Gordon might be found half a mile due northeast of Mt. Nebo church, if this spot has not been tested.

ALEPPO TOWNSHIP, ALLEGHENY COUNTY.

Aleppo lies south of Ohio township and north of the Ohio River. In it two oil pools, the Glenfield and Haysville, have been developed, together with a few scattered gas wells.

Glenfield oil pool. This pool is situated on the northeast corner of the area and extends over into Ohio township south of Stonedale. This is the largest pool yet found in the Fourth sand within the Sewickley quadrangle. The eastern border of this pool extends for two miles parallel to and just west of the axis of the Mt. Nebo syncline, the oil being found along the comparatively steep slope of the western flank of this fold. The oil producing area is triangular in shape, the three sides each being between one and one-half and 2 miles in length.

Data regarding the discovery and development of this pool are meager. The wells have nearly all changed hands, one or more times since, and most of the oil men who developed the field have scattered to other parts, so that but very little information regarding it could be secured in the limited time given to the study of this area. It is thought that the pool was opened up in 1895-96, and that many of the wells produced more than 100 barrels per day. The Fourth sand here ranges from 7 to 25 feet in thickness, and in many wells appears to be good pay all the way through. The records of only a few of these wells could be found. Those of wells Nos. 91 to 105 are given in tabulated form in the appendix. These records, though among the best obtained, are very incomplete, as they show only the depth to the top and bottom of some of the principal sands.

The Hundredfoot sand in this pool apparently ranges from 80 to over 100 feet in thickness, and evidently carries salt water in most of the wells.

The Gordon sand is from 10 to 30 feet thick and in a few wells has produced oil and gas, though the amount is not known. The Glenfield pool is approaching exhaustion. The best of the wells are now down to only a few barrels per day; a number show a production of one barrel or less per day, and many others have been abandoned. Little or no salt water is found in the Fourth sand in this pool.

Haysville oil pool. This pool is situated in the southern part of the township, in the vicinity of Haysville. It lies across the Ohio River from the northern end of the Coraopolis pool of Moon township, and is in reality a northern extension of the Third or Gordon oil sand, of that pool. The field now consists of some twenty wells occupying less than 100 acres along the slopes and crests of the river hills back of Haysville. Several wells drilled in this town are said to have produced oil, but no records of them could be obtained. The wells are now making a few barrels per day, and many have already been abandoned.

Near the southwest corner of Aleppo township and half a mile north of Glen Osborne, three or four wells (93) are pumping a little oil from what seems to be a separate pool from that at Haysville. No records of any of these wells could be found, and but little additional data regarding them.

The chance of finding more pools in this township seems exceedingly poor. Probably the best location left untested is half a mile north of the McIntosh well (93), on the north edge of the township, but the chances are against getting more than a small pumper. Producers will do well to consider this township thoroughly tested.

ROBINSON TOWNSHIP, ALLEGHENY COUNTY.

This township lies east of Moon and south of Ohio River, only a small portion of the northwestern part being within the Sewickley quadrangle. Most of this area seems to be oil producing in either the Hundredfoot or Gordon sand. Wells in the vicinity of Montour Junction produce from the Gordon sand, some gas being found in the Fourth. The Daniel Depp No. 1 well located just off the southern border of the quadrangle, about three-quarters of a mile southeast of 109 gets oil from the Hundredfoot sand, as does the Gibson No. 1 (111) which also found gas in the Gordon. The small cluster of wells about 1 mile south of Groveton were drilled in 1907 after field work on this quadrangle had been completed. No records of these wells have been secured. It is reported that they got oil in the Hundredfoot sand, but that the pay streak here is very erratic. Structurally there is no reason why this pool should not be extended to connect with the Depp development, and also northward to Groveton, but as said before, in an oil rock with only local lenses of open porous sand, the structure of the bed plays a secondary part in the accumulation of oil pools. The balance of this area seems to be well tested, and it is doubtful if any pools worth drilling for remain.

NEVILLE ISLAND, ALLEGHENY COUNTY.

This island is situated in the Ohio River east of Coraopolis. It is about 4½ miles long, with a maximum width of less than half a mile.

Neville Island has produced more or less oil throughout its whole length, though most of the oil has come from the eastern half of the area. In the W. A. Shank wells 112 and 113 at the western end of the island, the oil was found in the Gordon or Third sand. An examination of the map shows these to be a part of the Coraopolis pool, the wells being located just east of the axis of the Mt. Nebo syncline. The show of gas in the two wells 119 and 120 at the extreme western end of the island probably comes from either the Third or Fifth sands, though nothing definite regarding this point was learned in the field. It is known that the Fifth sand pinches out toward the northwest in this vicinity and in such a case the location of gas in a syncline along the upper margin of the bed is easily possible.

Eastward from well 113 the rocks rise rapidly to the crest of the pitching trough of the Wildwood anticline. Near the crest of this fold the Hundredfoot sand has produced considerable gas and a little oil on the J. W. Phillips farm (wells 114 and 115). This sand also carries salt water.

Farther to the east in the next group of wells the Hamilton No. 5 showed some oil and gas, with salt water, in the bottom of the Hundredfoot. From the structural map, Plate VI, it will be seen that these wells are grouped along the crest of a secondary arch, which branches off from the Wildwood anticline to the north. These three groups of wells are seen to be at nearly the same elevation in the Hundredfoot. Few good records could be found of wells in this area, and it is not known whether other sands are productive in these groups. To the east from well No. 117 and just over the southern border of the quadrangle and near the axis of the next syncline, the Kirk No. 2 well got gas and a flowing oil well in the Hundredfoot sand, also gas in the Third, Fourth, and Fifth sands. From a structural viewpoint this is one of the most unfavorable locations that one could select for gas in the lower sands. A clearly defined anticline crosses the Ohio River at the head of Neville Island, which lies within the Carnegie quadrangle. Along the crest of this arch good gas wells in the lower sands have been found on the Dixon, Cole, Bragdon, and Bailey farms. Most of this gas is thought to come from the Third and Fifth sands, though both the Fourth and the Hundredfoot are more or less productive of oil and gas.

This island seems to be well tested and there is little choice in the remaining untested areas.

KILBUCK TOWNSHIP, ALLEGHENY COUNTY.

Kilbuck township is situated east of Aleppo township and north of the Ohio River. The axes of two anticlinal folds which pitch rapidly southward, cross both the east and the west ends of this township. Near the crest of the western anticline which apparently is the main fold of the Wildwood anticline, several good gas wells have been found in what is called the Boulder sand. In well 122, on the Dixmont property, the thickness of the Boulder sand is given as 27 feet, with 10 feet of pay (gas) in the bottom, the Hundredfoot being the lowest sand carrying salt water. In well No. 123, on the same property, the gas is found below the Hundredfoot. Mr. J. G. Hoffman, who contracted for and drilled this well, states in his record that almost the entire interval below the Hundredfoot is occupied by sandstone, so that it was impossible to tell which horizon furnishes the gas. In another well on the Dixmont property (124) Mr. Hoffman reports 123 feet of Hundredfoot, 10 of Snee, and 40 of Boulder, with no Third, Fourth, or Fifth. A short distance east of this well on the Blanche D. Hutchinson farm (125) the tops of the Third, Fourth, and Fifth sands are noted.

It is thought that the Third sand furnishes the gas. In well 128, just south of 125, the gas seems to be accompanied by salt water, some difficulty being experienced in keeping the water from completely shutting off the flow of gas. No record of this well could be secured, and but little data regarding it was obtained in the field.

Well number 126 on the John F. Westbay farm about 1 mile north of Emsworth is one of two or three wells that have produced gas in the Fourth and oil in the Fifth sands.

Avalon oil pool. In the eastern part of Kilbuck township a considerable oil field has been developed in the Fourth sand, with some oil in the Hundredfoot and Third, and gas in the Fifth. Spirit levels were run to most of these wells, but only a few records of them could be found. The names and elevations of wells numbered 129 to 141 inclusive are given in the appendix. Some of these flow oil from the Fourth sand. The eastern part of the Avalon oil pool, which is in Ross township, will be discussed under that township.

There is little chance of finding new pools of oil in Kilbuck township. The best place in the township to try for oil is half a mile southwest of well No. 89. If the pay in the Hundredfoot is good, there is a fair chance of getting several small wells here. If the area southwest of 126 has not been tested. a well one-fourth mile in that direction would have a show in the Fifth sand, and would probably get gas in some of the sands. All other untested spots have about equal show.

ROSS TOWNSHIP, ALLEGHENY COUNTY.

A portion of Ross township occupies the southeast corner of the quadrangle. In it are the Perryville and a portion of the Avalon oil pools, and the Westview gas pool, beside several scattered gas wells that reveal no definite pools. Though more than the average amount of field work was expended in this township, the results obtained are far from being satisfactory, both as regards the structural map and the data regarding wells. Most of the wells in this township are old, many of them being abandoned. The records of these if preserved at all, are very incomplete, in many cases showing nothing but the depth to the top of the producing sand. Because of the age of the present producing wells and the fact that most of them have long since passed out of the hands of the men who drilled them, but little data of value could be secured in the field. Too much confidence should not be placed in the contours of the structure map, plate VI, in the southern part of this township. These lines are drawn here to show what appears to be the general shape of the folds, and any portion of it may be considerably in error. Sufficient elevations on wells were secured in this area to insure close structural work, but the records are lacking.

It will be seen that levels were run to a number of wells in the eastern part of the Avalon oil and gas field north of Bellevue. The elevations of the numbered wells are given in the appendix.

Bellevue oil and gas field. This field when first developed covered a considerable portion of the territory on which the town of Bellevue is now located. Most of this area lies south of the Sewickley quadrangle. The northernmost wells of this field are 156 and 158, on the southern border of the quadrangle. These wells have been pulled and their last owners could not be learned. The record of the Peter Ivory No. 1 well located about one-fourth mile southeast of 158 shows top of the Hundredfoot sand at 1,600, gas at 1,633, oil and some salt water at 1,634, total depth 1,636½. The George Orth No. 4, located about half a mile southwest of 146, got two pays in the Hundredfoot, and gas in the Thirtyfoot sand. This well is still producing. South and southeast of this well the oil is found in the Thirtyfoot sand.

West View oil and gas field. This field consists of several wells in, and to the southeast, of West View, which have produced more or less gas from the Butler gas sand (salt sand), Hundredfoot, Thirtyfoot, Snee, Boulder, and Third sands, and some oil from the Hundredfoot and Thirtyfoot.

Records of wells 143 to 147 inclusive, and those of the McCallum and McGee wells across the eastern border of the field have made it possible to depict fairly well the structure of this portion of the township. This shows that the gas wells at 143, and northward to 160, lie almost in the bottom of the canoe-shaped syncline with dry holes (161 and 162) in the sand immediately above.

This fact is of less value than it would be if it could be shown that the gas producing sand in well 160 continued good north and northeast from that point. In well 146, McCutcheon No. 1, the Snee and Boulder sands produce gas. In the W. H. Crider well 145, gas was found in the salt or Butler gas sand, the top of which is here 175 feet above the top of the Hundredfoot. Special attention should also be called to the fact that in the record of this well the Hundredfoot sand has water at 1,515, gas at 1, 525, and water at 1,530. Presumably the first water is above the break, the gas immediately below this shale division, and the second water in the pay streak of the lower section of this sand. Well 148 on the J. R. Sangree farm produced a limited amount of gas from below an 8-foot break of shale in what is noted as the Third sand.

Hammerschmitt oil pool. This pool is situated on the Hammerschmitt and Hartman farms, about three-fourths of a mile southwest of Perryville (see wells 149 and 150), at or near the axis of a synclinal trough which plunges rapidly to the southeast, and flattens out to the northwest against a dome of the Wildwood anticline. The Hundredfoot sand, from which the oil is produced, is here about 100 feet thick, and in some of the wells carries three distinct pay streaks, each ranging from one to fifteen feet in thickness. This sand produces salt water with the oil, the conditions being similar to those already described for the Leetsdale pool. The daily supply of salt water decreases the longer a well is pumped, and when the water is exhausted the indications are that the supply of oil will cease. This pool consists of seven wells, the total production being small.

Since the field work was done in this quadrangle, three or more oil wells (163) have been drilled on or near the John Link farm, half a mile west of Perryville. No records of these wells could be obtained, and it is not known which sand produces the oil. Half a mile northeast of Perryville the Third sand is said to produce from three or four wells on the Good farm. Though levels were run to some of these wells, no records of them could be found. A well in this vicinity on the David Real farm got salt water in the salt sand or Fortyfoot, which is above the Big Injun, and gas in the Butler gas sand, which is here called the Salt sand. This record is given as David Real Number 1, 2, or 3, and it is possibly of well 164, Plate VI.

A single well (167) on the Thomas Hartman farm produces a small amount of oil from what is supposed to be the Hundredfoot sand, since the well pumps salt water with the oil.

Probable productive areas in Ross township. Perhaps a considerable number of wells that have been drilled in this township are not shown on the map, despite the fact that inquiries were assiduously made in the field regarding the locations of old abandoned holes.

The best location in this territory for oil is doubtless from a half mile to a mile east and a little south of east from the Hammerschmitt pool. If this territory has not been thoroughly tested it is worthy of a test in the valley directly east of the Plank Road and opposite the first church on this road north from West View. In this area the chance is good for oil in the Hundredfoot and Third, and gas may be found in the Salt, Boulder, and Fourth sands. An oil pool in the Hundredfoot sand, if the pay is uniform, should be developed in a northwest-southeast direction. If oil is found in the Gordon the pool should be cautiously extended farther to the north and east. There is no structural reason why the Hammerschmitt pool should not be extended to the southwest and a short distance east of well 168, which is said to be a dry hole on a farm owned by the South Penn Oil Co. A well on the anticline half a mile north of 168 should get gas in some of the lower sands, and might develop oil in the Hundredfoot and Boulder sands. The same might be said of a location one-half mile a little east of north from well 167, and also in a less degree for a well half a mile southwest of 148. These locations have been named in what is considered the decreasing order of their value.

McCANDLESS TOWNSHIP, ALLEGHENY COUNTY.

The western portion of McCandless township, which is embraced by this quadrangle, lies north of Ross. Within this part of the township is included the southern end of the Wildwood oil pool, and a large portion of the Sandle pool, both of which have produced considerable quantities of oil from the Third sand. A number of good gas wells are scattered over most of the northern part of this area.

Sandle oil pool. This pool occupies a strip of country one and one-half miles long from east to west, and about one-half mile wide, near the southwest corner of the township. The Third sand, which is oil-bearing in this pool, is rarely over 25 feet, and frequently less than 10 feet, in thickness. In a few wells two streaks of pay from one to four feet thick are reported in the records. This pay is a fine conglomerate of white quartz pebbles which range in size from coarse sand to well worn pebbles as big as large peas. No water has been found in this sand. Most of the wells were drilled in 1895. None of them were large; few produced over 50 barrels per day.

The pool has long been down to a settled production, many of the wells now being practically exhausted. In at least one well, 175 (Sandle Heirs No. 4) both oil and gas were found in the Fourth sand. In the others this sand and the Hundredfoot, Snee, and Boulder, appear to be barren.

From the map it is seen that this pool lies along the northern slope of the Wildwood anticline about equidistant between the axis of this fold and that of the Mt. Nebo syncline, to the north. Practically no data is available regarding the location of the dry holes which doubtless surround this pool. Its structural position suggests that the Third sand might contain water in the shallow basin of the Mt. Nebo syncline to the north, but inquiries made of land owners in this vicniity failed to develop the presence of any drill holes, hence no direct evidence on this important point is available.

Wildwood oil pool. About half a mile east of the eastern end of the Sandle oil pool is the southern end of the Wildwood pool, which extends northeast to the vicinity of Wildwood, off the eastern border of the quadrangle. This pool is considered one of the largest ever found in the Third sand in southwestern Pennsylvania.

January 19, 1891, this pool made its maximum daily output of 18,000 barrels of oil. It was discovered in 1889 or 1890 near the northern end, and was developed southward. The first well to be drilled in that portion shown on the map was well 180, on the Austin heirs farm. It began flowing at the rate of 1,300 barrels per day. The development of this part of the pool was very rapid, and in a short time the oil-bearing area was encircled by a string of dry holes. All traces of these have long since been obliterated, and no attempt was made to locate them on the map. Data regarding a number of wells that have produced considerable oil, but have since been abandoned, is also hopelessly lost. The wells on the map are intended to show fairly well the present outline of the pool and practically all the wells that are now pumping. The production of the field is very small, the oil sand being almost entirely depleted.

The southern end of this pool is on the eastern side of the Wildwood anticline, at about the same elevation (1,470) as the eastern end of the Sandle oil pool. Few if any wells have produced oil here, that touch the Hundredfoot sand below the 1,450 contour. The upper limit of the pool seems to rise higher and higher in the Third sand northward to Pine Creek, the oil in the J. M. Moon well (189) at that point being at about 1,510. This location of the pool indicates a similar structural and water problem as that pointed out above for the Coraopolis pool, but from all the data available, and it seems to be fairly conclusive, no water is found in the Third sand in any part of the Wildwood pool shown on the map, and it is said on good field authority that the dry holes to the southeast of this area, and at a lower level, showed no water in the Third. It seems very reasonable to suppose that if this sand does contain water, it would have made its appearances in those wells lowest down the slope of the sand, and more nearly exhausted of their oil. However, apparently no water has been found in the wells along the southern margin of the pool, that have been pumped dry of oil and abandoned. If this is a fact, and there seems to be no evidence against it, the oil in the Third sand of the Willwood pool requires a somewhat different theory of accumulation from that of the Coraopolis pool, which in a structural way it so closely resembles. The essential object to be held in view in a study of these, and similar oil pools, is that of picking out such phenomena as furnish direct evidence regarding processes of accumulation, and grouping these in the way most conducive to a better understanding of the obscure laws governing the accumulation of oil and gas. From the limited evidence in this case it appears that Willwood and Coroapolis pools could not have been formed by the same process. In such cases, where the structural conditions are so similar, and one pool contains salt water while the other does not, it would seem that a single theory could hardly be equally applicable to both cases. To say in such cases that the evidence is not sufficient, is to retreat behind a bulwark of ignorance from which all facts may be assailed, and all deductions therefrom criticised.

In the southern part of the Wildwood pool, the Third sand is rarely thirty, often less than twenty feet, and sometimes less than ten feet in thickness. The pay streaks vary from 2 to more than 10 feet. It is remarkable that a sand with such a thin pay could have furnished such enormous flows of oil, but this is especially characteristic of the Venango group of oil sands.

The Hundredfoot sand, which is from 100 to 140 feet thick in this pool, is found to nearly always carry more or less salt water. In it no oil and not much gas have been found. Salt water is also found in the Salt, or Fortyfoot, Big Injun, and Butler gas sands. The Snee and Boulder sands are said to be without water, oil, or gas. The Fourth sand shows no water, but carries some gas in certain wells. No records in this pool mention the Fifth sand, though it is present in wells farther to the north.

Northwest from the Wildwood pool well No. 192 was the pioneer gas well in this vicinity, but little else was learned in the field regarding this well. Number 193 on the Adam Kyle farm is said to produce gas from the Fourth sand. The Philip Sarver well (194) gets its gas from the Third sand, the Fourth sand being only 5 feet thick in this well. The bunch of wells half a mile southwest of 194 is said to produce from the Fourth sand, though little else regarding them was learned. The same may be said of the gas wells shown on the map to the northeast. In well 196 on the William Toogood farm all the sands from the Hundredfoot to the Fifth are mentioned in the record, but the thickness of each is not given. It is not stated which produce the gas. On the William McKindley farm 197 and 199, some oil was found in the Third sand, with gas in the Fourth. The latter sand also produces gas in the Ed Greasler well 198, in which the Third is represented by "shell." Wells 200 and 201 on the Pierce farm, and 202 on the Louis Siple, got gas in the Fourth sand.

Undiscovered pools in McCandless Township. This township has been too thoroughly tested to admit of much more oil being found. Those spots that are still not drilled do not occupy good structural locations. Those places that might be suggested as offering the more favorable chances are named below in the order of their importance. A well located three-fourths of a mile due north of 172 in the Sandle pool might get production in the Third or Fourth sands. Another on the township line in the valley west of 195 should get a small pumper in the Third if this sand carries a good pay. A mile north of this point on the township line the Hundredfoot, Thirtyfoot, and Third all have a fair show of being oil-bearing if the sands are good. Little or no Fourth sand will be found here, though if the sand were present in good condition it would very likely carry gas. Half a mile east of this location oil might be found in the Third. There is also a bare possibility that the Third sand would furnish a small pumper half way between 196 and 197 with gas in the Fourth. All other untested spots in the township have about equal show.

FRANKLIN TOWNSHIP, ALLEGHENY COUNTY.

Franklin township lies west of McCandless and north of Sewickley, Sewickley Heights, and Ohio townships. The Duff City oil field in the northwest corner, the Ingomar pool in the south central part, and three or four wells in the extreme southeast corner of the quadrangle west of the Sandle pool, constitute practically all the oil-bearing territory within the township.

The four wells mentioned above are on the King, Hartman, and English farms. The record of the William English well, 204, gets its oil in the Hundredfoot sand, which is here 150 feet thick with 15 feet of pay 50 feet from the top of the sand. When first drilled in this well is said to have filled up 800 feet with oil and salt water. The daily production of oil, however, was small. The other wells of this group are said to get their oil from the Hundredfoot, with the exception of the Lena King No. 2, which produces from the Thirtyfoot. The wells were all small and are now pretty well pumped out.

Well 205 on the Thomas Richie is said to have furnished a small amount of gas, but no record could be secured of it. The Robert C. Wright well (206), which was drilled in 1888, is still furnishing gas to the pipe line from what are thought to be the Third and Fourth sands. Well No. 207 on this farm flowed considerable oil from what is stated in the record as the Fourth sand, but which appears to more nearly correspond to some portion of the Hundredfoot. It is possible that an error has been made in selecting the record of this well. The Wattenpool well, 208, is the first one of a northeast extension of the Hundredfoot pool at Ingomar begun in 1907. The record of this well is confidential data and can not be discussed. At the time of the writer's visit the other wells shown on the map were being drilled.

Ingomar oil pool. This pool gets its oil entirely from the Hundredfoot sand, which also produces water. The ratio of salt water to oil varies greatly in different wells in this pool, but from pool to pool the total daily amount of water pumped seems to bear no direct relation to structure. It seems reasonable to suppose that if the Hundredfoot sand is saturated with salt water over most of the area, pools located at low places in the sand would pump water longest. This is not true, either of separate pools or of individual wells in the same pool. As stated before, the life of an oil well in the Hundredfoot sand is dependent in nearly all cases upon the length of time that it can furnish salt water. In a few instances more oil than water is pumped, but usually the proportion is from five to thirty barrels of water to one of oil. Some of the wells in the Ingomar pool made as much as forty barrels of water to one of oil. Many wells in the Hammerschmitt, Sevins, Leetsdale, and other pools in this sand, with practically the same thickness of pay streaks, have made from one-half to one-tenth as much oil as water, though these pools are located at points from 50 to 100 feet lower down the slope of the sand. The percentage of oil to water seems to decrease with an increase in the thickness and porosity of the pay streak, though authentic data on this point are hard to secure.

Structurally it will be noticed that the Ingomar pool is situated well up the eastern flank of the Brush Creek anticline, and that the pool has a notheast-southwest trend parallel to the general strike of the rocks. In the William Neeley well, 219, gas was found in the Hundredfoot sand 7 feet from the top, with oil 42 feet below in the same sand, but as the record is very incomplete, this important item might have been omitted. It is said that in the John H. Piffer well, 337, a show of oil was found in the Hundredfoot, but that the pays were poor. Half a mile farther east, the D. V. Pegher well got gas, oil, and water in the Hundredfoot sand 42 feet from the top. This is at about the same horizon as the pay in the William Neeley well 219. Northwest of the Ingomar pool wells 221 and 222 on the George Smith farm found some oil and gas, and a large amount of salt water in the Hundredfoot.

Duff City oil field. This field lies along the axis and sides of a short anticlinal nose which juts out to the west from the Brush Creek anticline. It consists of developed portions of pools in the Snee and Thirtyfoot sands, and in addition a few wells in the Hundredfoot sand which form a southern extension of the Brush Creek field. The Snee, Boulder, and Thirtyfoot pools cover practically the same area and occupy nearly all the productive part of the Duff City field, which is tentatively considered as merging into the Brush Creek field at about the northern edge of Franklin township, though no arbitrary line can be drawn between the two.

The first well getting oil in the Snee sand in this vicinity, and the one in which the sand first received this name, is located in the southern portion of the Duff City field. In other parts of the oil region of Pennsylvania this sand is called the Blue Monday. It here ranges from five to probably less than 20 feet in thickness, but it is said to be very soft and porous where it carries oil, and has furnished a number of good wells. The Thirtyfoot sand in this field is usually somewhat thicker than the Snee, but its pay streak is thin and somewhat erratic in occurrence. It has however been a prolific producer in portions of this field. The Hundredfoot sand has shown more or less oil in a great many of the wells, but its pays are usually poor and it apparently carries less than the usual amount of salt water. In a number of wells the Boulder sand has produced considerable oil. Perhaps the best well in this sand is the J. Swint No. 1 well (224) which is said to have at first made 400 barrels per day. This well is still pumping after producing for 18 years. The Boulder sand also produces more or less gas from wells 229, 231, and 232. Records of wells in this field are very incomplete, and much valuable information has been lost beyond hope of recovery.

While the Duff City field has been producing oil for several years, a little development work is still being continued by operators in cautious extensions to the southwest, and it is probable that a few more producing wells will be added in that direction.

In this field attention is again called to the fact that the Thirtyfoot, Boulder, and Snee sands, which furnish nearly all the oil, are reported to be without water. Down the slope of the sand in wells to the west and south water has not been found, to the writer's knowledge, in a single instance in any of these sands. In most of the dry holes the sand was not as soft and porous as that of the oil-bearing areas. Here are in reality three distinct oil pools in as many sands, that have all collected on the crest and sides of an anticline, apparently without the assistance of salt water as a transporting agent through difference in gravity. In the same field and extending northeastward is also a more or less continuous pool of oil in the Hundredfoot sand, which contains salt water. From all appearances the oil and water come into the wells at the same time, and possibly together. There is no perceptible difference in the quality of the pay streaks that would favor either the Hundredfoot or the other sands.

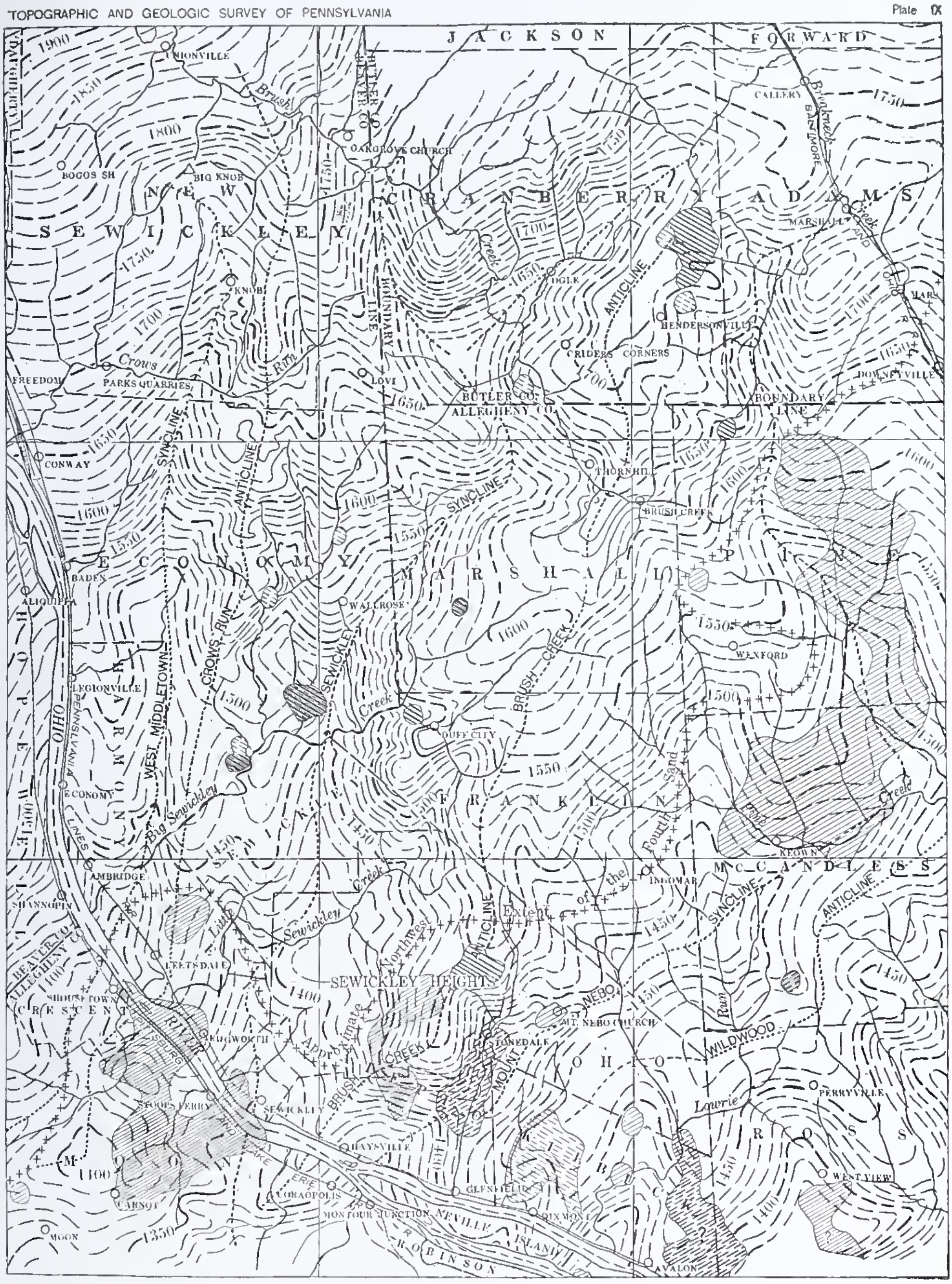
Probable undeveloped pools in Franklin township. In this township there are two or three places where the structure seems very favorable for new pools and where the other indications seem to point in the same direction.

The best of these places is probably about half way between and a little to the north of wells 219 and 221. If the Hundredfoot carries a good pay in this area it will be pretty sure to produce oil. In fact the chances are good for getting oil in this sand with gas in the upper pay, in any of the untested area lying between the Ingomar and Duff City pools south and southwest of well 236. The best location here is a little west of benchmark No. 65. There seems to be no good reason why a well located one-fourth to one-half a mile south to southwest of the D. V. Pegher well 238 should not get oil in the Hundredfoot. A well drilled on the northern boundary of the township a little west of north from this well should also get oil if the sand is good. It is probable that some oil might be found in the Third sand in a well drilled between one-fourth and one-half a mile due south of well 239 on the Vandevort farm. A small pumper might also be found in this sand one-half a mile west of 207. Other locations within the township seem to be of about equal value.

PINE TOWNSHIP, ALLEGHENY COUNTY.

Pine township is situated north of McCandless, and borders Butler county on the north. In this township a considerable pool of oil in the Hundredfoot sand has been found at Wexford, and scattered wells here and there have also made more or less oil from the Hundredfoot, Snee, Boulder, and Third sands. A portion of the Brush Creek field which is situated in Marshall township to the west of Pine, underlies the northwest corner of this township. Gas has been found in the Hundredfoot, Third, and Fourth sands, but the latter produces all or nearly all of that used commercially.

Wexford oil pool. This pool is situated on the crest of a steeply pitching anticlinal nose which juts out to the southeast from the Brush Creek anticline in the vicinity of Brush Creek. It will be seen that wells in this pool touch the Hundredfoot sand at about the same elevation as those in the Ingomar pool, and also the D. V. Pegher well (228) and wells 274, 275, and 276, in the extreme southeastern corner of Marshall township. In fact it seems that wherever a good open pay with salt water is found along this belt, oil has been present. Extending northeast from the Wexford pool, a more or less continuous line of wells marks the same level to the small pool on the English and Fogal farms (225 to 257). Here the pool is almost in the trough of the Mt. Nebo syncline, though still at the same level as the Wexford pool on the crest of an anticline. Only a single pay streak ranging from 25 to 35 feet below the top of the Hundredfoot sand is



LOCATION OF KNOWN OIL AND GAS POOLS IN THE BOULDER AND FOURTH SANDS IN THE SEWICKLEY QUADRANGLE

▨	▨	▨	▨	▨	▨
Gas in Boulder sand	Oil in Boulder sand	Oil and gas in Boulder sand	Oil and gas in Fourth sand	Oil in Fourth sand	Gas in Fourth sand

Contours are drawn on top of Hundred-foot sand which on this map may be considered to lie parallel to top of Boulder and Fourth sands.
Datum plane for contours 2000 feet below sea level. Numbers show distance in feet above this plane.
In areas where contours are not drawn the available data is not sufficient to admit of the delineation of the structure

generally reported in records of wells in the Wexford pool. This pay sometimes reaches a thickness of 20 feet, though it is said to be frequently less than 10 feet.

This pool was opened up from 1894 to 1897, but a small amount of drilling is still going on along the southern edge. Though a number of good wells were struck, few of them are said to have made over 100 barrels per day. These are now pretty well pumped out, and some wells along the northern extension of the pool are abandoned. It is said that some of these wells were drowned out by the incursion of salt water from one of the upper water-bearing horizons, presumably through the faulty plugging of some unproductive well. This is hearsay knowledge, picked up in the field, there being no ready means of verifying it.

From the map it will be seen that the Fourth sand contains gas throughout most of the eastern third of Pine township. As a rule the wells are small or only average producers, though now and then a good well is found.

The initial minute pressure in a 2-inch pipe, in most of the wells, ranged from 70 to 200 pounds, though the maximum is probably about 350 pounds. The initial rock or closed pressure varied considerably in relatively short distances, the maximum being about 500 pounds per square inch.

The Fourth sand is very thin over this area, seldom being more than 15 feet, and frequently only five or six feet thick. Considering the thinness of the sand and the minute pressure of the gas, the wells hold up remarkably. In many drilled from 10 to 15 years ago the minute pressure is from one-half to one-fourth of the initial one, and the rock pressure more than half what it was at first. As may be seen by an examination of the list of records in the appendix, the Third, Boulder, and Snee sands are thin or entirely absent in this township. In the northern part of the area the Snee and Boulder have furnished oil in a number of wells. The Third sand was found in the Robert Kennedy (264), J. C. Martin (265), J. C. McDonald (270), Dr. List (266), and the Porter (263) wells, with a thickness of from 4 to 10 feet. In 264 this sand furnishes the oil.

No water is reported in any sands below the Hundredfoot, and this sand apparently carries much less water in the eastern half of the township than elsewhere in it.

A peculiar fact was noted of the occurrence of salt water in the Hundredfoot sand in wells 255, 256, and 257. Well 255 is No. 2 on the Henry Fogal farm. In it a slight show of oil and about 5 barrels of salt water per day were found, the sand not showing good pays. In 256 on the Andrew English farm, the Hundredfoot had 5 feet of fair pay which started off at 1½ barrels of oil per day to 30 of water, but was abandoned and pulled within less than a month and a half after it came in. This well is 5 feet higher on the sand than 255. Two months later a well (257) was drilled on the Joe English farm a short distance northwest of 256, and 8 feet higher on the sand, which started off with a production of 80 barrels of oil and 500 barrels of salt water per day, and in the first year made a daily average of over 40 barrels per day. After twelve years this well is still pumping 1 barrel of oil, to 10 of water. In this well three pay streaks were struck. The first, which corresponds to the pay in 256, was only 4 feet thick, but carried oil and water. The other two pays, each 2 feet in thickness, were 8 and 18 feet respectively below the first, and each carried oil and water. In this instance as in many others that might be cited, the salt water that makes its way through the sandstones in sufficient quantities to be noticed, travels along more or less continuous layers of very open porous conglomeratic sandstone, and from the facts given above it seems that quite narrow bands of less open rock make effective barriers to water under considerable pressure. There is no reason for thinking that the closer, harder portion of the Hundredfoot sand has not about the average porosity of fairly pure sandstone of average grain. In other regions sandstones of this type have yielded immense amounts of water, oil and gas. In fact sands above the Hundredfoot carry water in some parts of the Sewickley quadrangle where they are apparently no more porous than the closer portion of this sand here. It is not known to what height the water at first arose in well 256. Doubtless if the original height of the column in each had been recorded, the facts as they now stand could be explained by considering the water to be under hydraulic and not hydrostatic pressure, and there is a strong probability that these facts if available would tend to show that the source of the water is somewhere up the slope of the rocks toward the north or northeast. In this direction, however, the Dean well (269) showed no pay in the Hundredfoot until it was penetrated 67 feet, but oil and water were found only in the last 8 feet of the sand. In the McDonald well (270) 5 feet of pay was found 60 feet from the top of the Hundredfoot, and 88 feet in some salt water was found. In the I. S. Marshall well the Hundredfoot carries two 10-foot pays 53 and 88 feet from the top of the sand. No water is mentioned in the record. In this well both the Snee and Boulder sand produce oil. The Snee is 23 feet thick, with 3 feet of pay. The Boulder has a total thickness of 7 feet. Number 2 on the C. Wilhelm farm (273) has 4 feet of pay 3 feet in the Hundredfoot, and another 2 feet thick 78 feet from the top. Both of these pays apparently furnish oil and water, the initial production being six times as much water as oil. January 1, 1907, this had increased after pumping 12 years to 8 times as much water as oil.

These pay streaks are lenses of pebbles and coarse sand enclosed in the Hundredfoot sand. They form little irregular patches of loose, open rock in the somewhat hard and compact sandstone. The examples just cited, which are typical, show that these pay streaks are nearly always only a few feet in thickness, and pinch out in every direction within very short distances. This is characteristic of the Hundredfoot sand throughout the quadrangle. Wherever a good pay is encountered with plenty of salt water, there has nearly always been found a greater or less amount of oil.

Possible locations of new pools in Pine township. This township has been well tested, and no undrilled areas stand out prominently as prospective oil territory. Probably the best remaining chance to open up a new pool is by a well near the southwest corner half a mile northwest of 276. This well should reach the Hundredfoot sand at about the same level as the Wexford pool to the east, and about 10 feet higher than the sand at Ingomar. There is little doubt that most of the remaining oil will be found in the Hundredfoot sand. Since a belt of territory between the 1,500 and 1,550-foot contours embraces practically all the producing territory in this sand on the eastern slope of the Brush Creek syncline from Grubbs oil field in Ohio township to the English pool in the central part of Pine, we may reasonably consider that untested portions of this belt having favorable structural features offer better chances than do equally favorable structural positions located elsewhere. In the southwest quarter of Pine township and the northern part of McCandless, the data from which the structural contours were drawn are meager, and the chances are very much against this being correct in detail. The contours here simply represent the preponderance of evidence. Because of this fact the writer does not feel justified in especially urging the location mentioned above. He also does not wish to widely recommend a southern extension of the Wexford pool, but if the structure is reasonably correct, and the Hundredfoot carries a good pay in that area, there is no reason why the accumulation can not extend for three-quarters of a mile due south from the present edge of that pool. In this area gas will be found in the Fourth if it is present in sufficient thickness, and also the chances are fair for a show of oil in the Third if it has not pinched out to hard "shells" in this vicinity. Summing up this spot it may be said that it is probably worth a test to the Hundredfoot, but the chances for oil in lower sands would hardly justify continuing the well to their horizons. In the area between the Wexford pool and well 258, and from 242 to 257, the writer feels positive that wells have been drilled that are not shown on the map. The locations of these being unknown, any statements regarding this territory would be of little value. If no wells have been drilled here the best location is one-half mile a little west of north from well 244. If oil is found here the pool should be extended east and west. As mentioned above, the English pool (255 to 257) is a rare location for oil in the Hundredfoot sand. While in the field the writer was informed that dry holes had been drilled to the southwest and northwest of these wells, but he did not have the opportunity to look them up. If this is true, the best directions in which extensions might be made to this pool have probably been sufficiently tested. From the nature of the structure and of the pay streaks in the sands in this township, the chances are that several tiny pools of oil exist here, but it is very doubtful if they would repay the cost of their development, and on the whole, oil men will do well to look for more favorable territory elsewhere.

MARSHALL TOWNSHIP, ALLEGHENY COUNTY.

Marshall township is west of Pine, and forms the northwest corner of Allegheny county. In this township an immense amount of oil has been produced from the Hundredfoot, Snee, Boulder, and Thirtyfoot sands, the Hundredfoot being the great oil-bearing bed of the township.

Brush Creek oil field. This is the largest oil field within the Sewickley quadrangle. Broadly, the field includes a belt of productive territory from three-fourths to one and one-fourth miles wide, on the crest and eastern flank of the Brush Creek anticline from Duff City to the northern edge of the quadrangle north of Callery, a distance of more than 10 miles. This field is subdivided, however, into several local pools and fields which merge more or less completely into each other. One of the most important of these pools, and the one from which the field gets its name, occurs in the Hundredfoot sand in the vicinity of Brush Creek in the northeast corner of Marshall township. This pool also extends into Cranberry township on the north, and southward entirely across Marshall township into the Snee and Boulder territory of the Duff City field. Within the territory occupied by this pool in the Hundredfoot sand, oil-bearing areas of limited extent in the Boulder, Snee, and Thirtyfoot sands have also been found.

Throughout this pool practically the same conditions prevail as have been described in previous discussions of pools in the Hundredfoot sand. This bed here consists of from 80 to 125 feet of close, hard, medium-grained sandstone, with a shale break of from one to twenty feet in thickness near the center. Within this sandstone occur lentils of a softer, more porous, conglomeratic sandstone, which range from 0 to 20 or more feet in thickness. As many as three of these softer zones are often found in a single well.

The ratio of water to oil throughout this field varies considerably in even adjacent wells. In well 287 on the G. I. Sickles farm the initial production was 61 barrels of oil to 75 of water. After 7 years this well produced 15 times as much water as oil. On the same farm well No. 288 made 70 barrels of oil to 50 of water, which in 7 years changed to 5 barrels of water to 1 of oil. Well 289 on the same farm made 40 barrels of oil to 150 of water when first drilled in. After 6 years this ratio is still preserved. In these wells a single pay was found about 3 feet from the top of the sand which is respectively 14, 22, and 21 feet thick. It will be noticed that well 289 with the thickest pay holds up the best ratio of oil to water, while 288 with 21 feet of pay and with the greatest initial ratio of oil to water now pumps a greater ratio of water, while 287, with the thinest pay, shows the greatest increase of water to oil. The sand in 289 is 4 feet higher than it is in the other two wells.

The first six wells on the G. I. Sickles farm first produced from the Snee sand, which is said by Mr. James Livingston, District Superintendent of the South Penn Oil Company, to whom the writer is indebted for much valuable data, to have been very productive. When this pool was exhausted and abandoned, the property was purchased by the South Penn Oil Company, and tested in the Hundredfoot sand with good results. No records were obtained of the Snee sand in this vicinity, but southward in this field to the township line, the Hundredfoot, Snee, Boulder, and Thirtyfoot sands are oil-bearing in a greater or less number of wells. Few records of wells in this area were found, and the detailed history of this portion of the field is not known.

In the Amos Mashey well (290) the pay streak is 6 feet thick, and 2 feet from the top of the sand. In the Robinson Heirs well (295) the first 20 feet of the Hundredfoot is pay sand, and a second pay 12 feet thick was found 41 feet from the top. In well 296 on the same farm the first pay consists of 17 feet at the top of the sand, while the second is 10 feet thick and 43 feet from the top.

In the M. Steigerwald No. 1 well (305) a single pay 15 feet thick was found 60 feet from the top of the Hundredfoot. This made 10 times as much water as oil, which increased to 12 times after pumping seven years, with a falling off of about seven-eights from the initial daily production of water.

In the John Warren well (300) no record is available of the Hundredfoot production, but when this well was drilled into the Snee sand on November 20, 1889, it started off at 200 barrels of oil per day with no water, in a sand only 10 feet thick. After 18 years this well is making 3 barrels per day. Little information is now available regarding the extent of the producing area of the Snee sand in this vicinity, but it is said to have furnished a large quantity of oil, before the Hundredfoot sand was thought to carry oil in sufficient quantities to justify pumping. Later when many of the wells were exhausted in the Snee, the casings in them were pulled, to above the Hundredfoot, and that sand put to pumping. In the William Lloyd No. 3 well, located about half way between wells 298 and 299, two pays were found in the Hundredfoot, 3 and 48 feet from the top. These aggregate 14 feet in thickness, and had an initial production of three and one-third times as much water as oil, which in 6 years increased to 4½ barrels to one of oil, with less than one-third the daily production of water The first well east of the William Lloyd No. 3, has two pays, the same distances from the top of the sand, and at the same elevation, with a total thickness of 19 feet. This well came in 8 months after Lloyd No. 3, with an initial flow of only about one-fourth as much oil and one-fifth as much water. The William Lloyd well (298) shows a single pay 57 feet from the top, in which the well first made over 6 times as much water as oil, which in five years increased to 8 times as much water as oil, with less than one-sixth the initial daily production of water. The W. & J. Warren well (299), located seven feet lower on the sand, got a pay 2 feet from the top of the sand, another 52 feet in, and a third 60 feet below the top of the sand. The aggregate thickness of these porous streaks is 32 feet, and the well began with three and one-half times as much water as oil, which ratio was doubled at the end of 2½ years with a decrease of one-half in the daily production of water.

In the northeast corner of the township, on the J. B. Smith farm, somewhat different conditions prevail. Well 306 shows the top of a 15-foot pay 5 feet in the sand, and another 13 feet thick 55 feet from the top. These made nearly twice as much water as oil, which in 3 years was increased to ten times as much. The water had decreased to less than one-seventh of its original daily capacity.

Continuing northward from 306, No. 307 on the same farm shows three pays, 4, 16, and 56 feet from the top of the Hundredfoot, with a thickness of 2, 12, and 8 feet respectively. This well is 1 foot higher on the sand, and its aggregate thickness of pay is 6 feet less than that of 306, yet this well made nearly twice as much oil and exactly twice as much water as that one. It had the advantage, however, of being drilled in three months ahead of well 306. Well No. 308, which commenced producing January 4, 1907, made ten times as much water as oil. On March 1, 1907, the daily production of water had decreased 10 barrels per day, with no change in the production of oil. Only one pay 5 feet thick and 6 feet from the top was found in the sand. The J. B. Smith well No. 10, located half way between 308 and 309, commenced producing October 4, 1906, from two pays 2 and 10 feet from the top of the sand with a thickness of 3 and 10 feet respectively. This well started off with nearly seven times as much water as oil, and on January 1, 1907, the production of water had decreased

25 barrels per day, while that of the oil remained the same. No 309 came in February 23, 1906, with five times as much oil as water. On January 1, 1907, the production of oil had decreased five-sixths, and that of water one-third, so that in this well the ratio of oil to water had decreased from one-fifth to one-eighth. This well has two pays, the first 8 feet from the top of the sand and 8 feet thick, the second 53 feet from the top and 5 feet thick.

In the last two wells the sand is at practically the same level, the pays in each aggregating the same thickness, but the Smith No. 10, which was drilled 8 months later than 309, produced nearly a fourth more oil and almost twice as much water as the other. This fact can not be explained by assuming that the pay which ranges from 48 to 58 feet below the top of the Hundredfoot, carries a less ratio of oil to water than the upper pay, for most of the evidence seems to point to the conclusion that this middle pay is the most productive of both water and oil. However, sufficient data are not available to settle this point.

On the western edge of this field the pay in the Hundredfoot sand is confined to a single streak, in wells 310 and 311 on the Douthett farm. Here it is 36 and 38 feet respectively from the top of the sand. The amounts of water and oil are not given in the records.

There is little doubt but that these lentils or pay streaks carry all the oil, gas, and salt water that is noticeable in sinking a well through the Hundredfoot sand. The horizontal extent of each of these pay streaks can not be accurately worked out from the records that have been preserved, but they doubtless vary in size from patches of an acre or less to those covering several square miles. Experience in this pool, as well as in numerous others, indicates strongly that the oil and salt water come out of the pay streak together. As previously shown for other pools, a definite amount of salt water and oil may be pumped from some wells each day, after which but little oil or water can be obtained until it has time to again collect in the well. In such cases the oil may collect at the top of the head of water in a well, and the pump be so stationed that it may give either oil or salt water almost exclusively for a portion of the time it is being pumped. In other wells the pump is kept running continuously day and night. In such cases the oil and water come out of the well in probably about the same ratio as they enter the hole from the pay streak. There is no way of determining whether the oil and water is mixed together as it enters the hole, but owing to the fact that as much as two or three hundred barrels of oil and 1,000 to 1,500 barrels of water have been produced daily from a pay streak only 5 or 6 feet thick, it seems evident that in some cases at least the oil and water are closely associated, if not mixed together, while in the sand, and that the assorting process takes place by difference in gravity after this mixture enters the well. Again, in drilling into a pay streak the work sometimes happens to be done in such a way that only the very top of the pay is broken. In some such cases the fluid which made its appearance in the hole was almost pure oil. In others it contained about the same relative amounts of oil to water as were later pumped from the well. The data for these statements do not appear in any record of wells, but have been picked up bit by bit by questioning a large number of oil men throughout these fields.

From this data the writer seems justified in stating as a fact that a considerable portion of the oil of the Brush Creek field is found mixed with water in the thin pay streaks of the Hundredfoot sand, and that in many such cases the entire mass of the pay streak seems to be saturated with this mixture. This lentil of pay sand in turn is enclosed by the closer, harder sandstone, in which no water can be detected. Positive data on this question of water in the harder rock can not be had, because it is possible that if this bed is saturated, it might give up its water too slowly to be detected in wells sunk by the churn drill method.

In this case when the evidence is summed up, the fact still remains that to all appearances we have here separate pools of oil and water, with more or less gas, located in isolated patches within a presumably dry sandstone. This fact becomes more perplexing when we remember that nine-tenths of these oil-bearing areas occur at or near the axes of anticlines

Southeast of the Brush Creek field oil has been found at but one place in Marshall township. In this pool only three wells (274 to 276) had been completed January 1, 1907. The oil in these wells comes from the Hundredfoot sand, which in wells 274 and 276 on the Shenot farm is at distances of 60 and 51 feet respectively from the top of the sand. In well 275 on the Sarver farm, two pay streaks were found, 10 and 45 feet in the sand. Some development work was being done in this pool at the time of the writer's visit, and the chances seem to favor its extension to the northeast if a good pay streak can be found in that direction.

In the extreme southwest corner of the township a small oil pool has been developed on the Zimer and Neely farms. Oil in this pool comes from the Snee sand, which is here about 15 feet thick. The wells are small and the area seems to be thoroughly tested, though it is possible for a small extension to be made for a short distance to the east and southeast, if the pay remains good. At the southern end of this pool a little water is reported in well 283 above the break in the Hundredfoot, with considerable gas in the sand immediately below this shale "break." In this well oil was found in the top of the Snee sand.

Less than a mile northeast of the above pool a well (285) drilled on the J. A. Montgomery farm found considerable water in the Hundredfoot sand, with both oil and gas in the Boulder. For several years the light flow of gas from this well has been used by Mr. Montgomery for lighting and heating his residence. The well has never been pumped for oil, though it would probably make a barrel or so, per day.

The southeastern extension of the Crows Run oil pool has a few wells on the Altman, Bridenstein, and Neeley farms on the western border of Marshall township. Of these wells 317 and 318 have 20 feet of pay in the top of the Hundredfoot, from which considerable quantities of oil and water have been produced.

Prospective locations for new oil pools. In this township the area lying east of the Brush Creek anticline seems to be pretty thoroughly tested, though it doubtless contains small pools of oil in the Hundredfoot at various places. In the western portion the pay streaks are wanting in almost all the tests that have been sunk, and if these productive patches exist here they are each probably of only a few acres in extent, and for this reason may be oil-bearing at almost any structural horizon. Again, in this area, the geologic and well data from which the structural map was constructed is meager, and the contours as shown on the map may be in considerable error. In this connection it should be stated that there is some question in the writer's mind as to the exact position of the Sewickley syncline in this township. From the well record data this trough appears to pass to the west of well 312, but this evidence is so clearly contradictory to that secured from spirit level elevations on surface rocks, that he has felt inclined to favor this data, and tentatively represent this trough as passing east of well 312. The record of this well (Thomas Crea No. 1) was furnished by Mr. James Livingston, and there can be no doubt as to its accuracy, but the records of four other wells are needed to definitely settle this question. These are 319, on the southeast, on Henry Bridenstein's farm; well 314 (Nicholas Shable No. 1); 320, on Dr. Gilliford's farm, and well 313 (Thomas Crea). Without this data suggestions as to favorable locations for tests would be based on too little geologic evidence to justify operators to consider drilling on the strength of it.

HOPEWELL TOWNSHIP, BEAVER COUNTY.

Most of this township lies west of the Sewickley quadrangle, but a narrow strip is included between the western boundary and Ohio river, from Crescent township northward.

In this portion of the township the Hundredfoot has produced oil in the Shannopin pool, along the southern border. Three old wells were located in Woodlawn, but no data concerning them was secured, except that well 326 on the C. S. McDonald farm got gas in the Hundredfoot. Well 325 on the Gailey and Richie lot was drilled in 1907 and is said to have found gas in the Hundredfoot. This is the northern extension of the large gas pool in the Hundredfoot at New Sheffield in this township several miles to the southwest.

The writer knows little of the condition of the oil sands in this area, and for this reason does not feel justified in suggesting locations for test wells, though in a general way it looks as if a well one-half mile southeast of 326 might get oil in the Hundredfoot.

HARMONY TOWNSHIP, BEAVER COUNTY.

Harmony township lies east of the Ohio river opposite Hopewell, and north of Leet. This township is small, probably covering less than 6 square miles. The Economy-Legionville oil field probably covers half this area.

Economy-Legionville oil field. Only a small portion of the wells in this field are located on the map, Plate VI. The pool occupies the pitching crest of an anticlinal spur lying to the west of the West Middletown syncline. The producing sand is the Hundredfoot, which in this field ranges from 20 to 25 feet in thickness. Gas accompanies the oil in many of these wells in such quantities as to flow the oil. Salt water is also present in many wells, though the amount is not as great as that observed in this sand in the Brush Creek field of Marshall township, which is from 150 to 200 feet higher up the slope of the sand. Many wells of this field have been large producers, some having an initial prodnction of 100 barrels per hour, and 1,600 per day. The total production of oil from this pool has been enormous.

The pay streaks of the Hundredfoot sand here bears a close resemblance to those described in other pools of this sand, and for the purpose of pointing out certain peculiarities of these wells, a number of them will be discussed in some detail.

In well 328, the top of the pay is 3 feet in the sand. Thickness of same and amount of production not given. In 329 oil was found in the first 3 feet of sand, with the top of a second pay streak 6 feet thick, 5 feet from the top of the sand. Well 349 had oil and gas for 2 feet in the top of the sand, below which was one foot of hard sand, then 6 feet of pay which flowed 15 barrels of oil the first day and 24½ barrels the second. Below this pay was 12 feet of closer, darker sand. In the next well to the northeast (330) the top of the pay was found 3 feet in the sand The record of this well does not give initial production, but in 331 a few hundred feet northwest of it, the oil was found 7 feet from the top of the sand, which with 6 feet of pay flowed at the rate of 50 barrels per hour. Well 332 found the top of a 7-foot pay less than 2 feet in the sand. The production of this well is not given.

This group of wells shows that practically all the oil comes from the upper portion of the sand. There is no way of determining whether the 20 odd feet of sandstone which makes up the total thickness of the Hundredfoot sand in this township, really represents in full the horizon occupied by this bed where it is 100 to 140 feet thick. It is possible that either the top or bottom member of this sandstone is represented by sandy shale in this area, and to the northwest. This question can not be settled by a comparison of intervals to upper beds, for the reason that of the 75 or more records received of wells in this pool, but one shows measurements to beds above the Hundredfoot, and only ten give the distance below to the gas sand, which the drillers call the Fourth sand. This sand in Leet and Crescent townships lies 307, 307, and 315 feet below the top of the Hundredfoot in wells Nos. 40, 45, and 51, respectively. In Harmony township the gas sand in well 328 is 301 feet below the top of the Hundredfoot. In other records of wells not located on the map it is given as follows:

Distance from top of Hundredfoot sand to top Fourth (?) or gas sand in Harmony township.

Name of Well.	Farm number.	Owner.	Distance from top of 100-ft. to top of 4th.	Production.
Economy property,	1	P. M. Shannon,	283	Gas.
Economy property,	4	P. M. Shannon,	286	Gas.
Economy property,	5	P. M. Shannon,	297	Gas.
Economy property,	8	P. M. Shannon,	313	Gas.
Economy property,	10	P. M. Shannon,	312	
Economy property,	11	P. M. Shannon,	316	
Economy property,	17	P. M. Shannon,	316	Gas.
Economy property,	20	P. M. Shannon,	303	
Economy property (deep well),	44	P. M. Shannon,	248	

Without accurate descriptions of rocks intervening between these beds it is impossible to determine from the above data whether the sand here reported as the Fourth is in each case the same horizon, but it will be seen that this data is of little value in attempting close correlations. The interval between the Ames limestone and the Hundredfoot sand is too great, and its variation too rapid to be of use. In this, as in most other cases, it must therefore be taken for granted that the intelligent, observant driller who has put down a number of wells in the same vicinity, has an infinitely better local knowledge of the succession of rocks through which his drill passes than the geologist can possibly get by studying the imperfect records which he has kept of his work. In questions involving local correlations of underground beds, the driller's classification of sands is doubtless in many cases the more nearly correct one. Such a correlation as mentioned above if possible, would be of value in determining the extent of the water-bearing zones in the Hundredfoot sand. No mention is made of salt water in the group of wells (328 to 332) discussed above, but farther to the north all wells on the leases of P. M. Shannon (more than 60 in number) have furnished a greater or less amount of salt water. In well 336 there is 10 feet of coarse pebbly pay at the top of the sand, which is 20 feet thick. This well, which touches the sand 20 feet higher than 332, produced 15 barrels of oil and some water when drilled in. South of 336 are several holes in which it is said no oil was found. Well 337 also has the same thickness of pay, and the same initial production as 336, but it is 9 feet lower on the sand. No. 338 gets its oil and gas from a 5-foot pay of fine white sand 16 feet from the top of the Hundredfoot, which is 23 feet thick. Well 339 has an 8-foot pay of fine, soft white sand 8 feet from the top. This well had an initial capacity of 18 barrels as against 10 barrels in 338, which was drilled later. Both made considerable gas and some salt water. In well 340, which produces gas from the 8-foot pay 8 feet from the top of the sand, the pay streak is 5 feet lower than it is at 339. In this well the pay is coarse and pebbly, and the well is a good gasser. It will be recalled that a similar case where gas was found at a lower level than the oil was noted above in the southwest side of the Leetsdale pool. Still farther to the north, well 341, which is located at a point 20 feet higher on the sand than 340, gas was found in the top of the sand and oil and gas 13 feet below in an 8-foot pay composed of fine white sand. The production of both oil and water was small. In 342 no gas is mentioned in the top of the same, but oil, gas, and salt water occur in 60 feet of pay, 10 feet from the top. This pay is fine, soft, white sand. The production was 30 barrels of oil to two of water. The top of the sand in this well is 3 feet higher than it is in 341. The writer is not sure that he has the right farm number for well 343, but if it is Economy property well No. 34 by P. M. Shannon, the top of the sand in this well is 21 feet higher than it is in 342. This well made 25 barrels of oil to one-half barrel of water, from a fine white pay sand 10 feet thick, and 10 feet from the top. The total thickness of the Hundredfoot sand was 23 feet. Practically the same conditions prevail in the other wells of this group, as have been shown for those above, except that no water was found with the oil in 345, though it is 15 feet lower on the sand than 343. Twenty-seven feet of sand with no pay was found in 347. No record of 348 is available.

In the limited time alloted to work in this field it was not thought advisable to attempt to hunt up and run levels to all the holes that have been drilled, and for this reason only the more accessible wells are shown on the map. In the area encircled by wells 337, 342, 347, and 348, doubtless a large number of holes have been sunk. From information furnished by Mr. Clair McCormick, Field Superintendent for P. M. Shannon, and than whom no man has a more detailed knowledge of the conditions under which oil is found in this field, the Economy-Legionville pool is in reality made up of a number of small pools having no known connection. It appears that we have here in miniature what has been shown to occur in the Brush Creek field on a much larger scale, namely a number of oil, gas, and water bearing patches of sand enclosed in a larger sandstone of greater density, in which none of these products occur in perceptible quantities. As regards salt water in this field, Mr. McCormick says that it is present in nearly every producing well on the Shannon lease, but that most of the water, as well as the oil, occurs below the break in the Hundredfoot From this it is presumed that the shale break occurs from 8 to 10 feet from the top of the sand, in the wells north of 336. South of this well the production in those on the lease of the South Penn Oil Company (332 to 328) found the oil at or near the top of the sand. Mr. McCormick also states that most salt water occurs on the eastern side of the field. One of these wells which twelve years ago came in with a production of over 100 barrels of oil and 12 barrels of water, now makes 1 barrel of oil and five of water. Other wells producing 40 to 60 barrels of oil and a barrel or so of water after eight years still show about the same amount of water, though the production of oil has greatly diminished.

Only three wells on the Shannon lease have produced relatively large amounts of water. These, as stated above, are on the east side of the field. From the map it will be seen that the producing sand is at a lower elevation on the eastern than on the western side of the field, and it is possible that this is the reason why more water is found there. This will not hold good, however, for the gas well, 340, and for the wells at the extreme southern end of the field. But little data could be secured regarding the condition of the Hundredfoot sand, outside this pool, but in most test wells it is said to be hard and close, with no oil, gas or water.

Prospective oil territory in Harmony township. There is little chance of finding much new production in the township outside the Economy-Legionville pool, though to repeat, small pools may be found at any place where the Hundredfoot has a good pay, but the chances are best along the crest of the anticline. The same may be said of gas in the Fourth. No other sands offer inducements for drilling, the Thirtyfoot, Snee, Boulder, and Third being absent over practically all of this township.

ECONOMY TOWNSHIP, BEAVER COUNTY.

Economy township lies northeast of Harmony and west of Marshall township. The middle of the area is traversed from north to south by the Crows Run anticline, and the West Middletown syncline, the axes of which are from one-half to one mile apart. The Sewickley syncline crosses the southeast corner with a northeast-southwest trend.

The Davis, Craig, Cookson, and Economy-Legionville oil pools make up the producing areas in the southern and central parts of the township, and a large part of the Crows Run pool occupies the northeastern part. The northwest quarter of the township appears to be particularly barren, a few gas wells in the vicinity of Baden, and a half dozen small pumpers on the Straube, Dunn and Ehrman farms a mile or so north of that point constituting practically all the oil and gas found in this part.

Davis oil pool. This pool is located on the A. M. and J. H. Davis farms, in the valley of Big Sewickley Creek near the center of the southern border of the township. At the time of the writer's visit the pool was producing from only four wells, though a few other wells have produced some oil and gas. Of these the J. H. Davis No. 7 (355) flowed a barrel or so per day from the Boulder sand. The two wells (336) on the A. M. Davis farm are pumping a small amount of oil from the Hundredfoot sand. J. M. Davis No. 2, located northeast of 355 gets gas in the Boulder. Pay streaks in the Hundredfoot sands are wanting in most of the holes drilled, the sand being very hard and close. In the producing wells the pay is thin, and furnishes a small amount of water with the oil. Water was also found with a show of oil in this sand, in the J. H. Davis No. 3, located southwest of well 355. The Boulder sand has shown no water in any of the holes. The pool seems to be entirely developed, and there is little chance of finding an extension to it. This pool appears to occupy the crest of a slight anticlinal nose which juts out to the southeast from the Crows Run anticline.

Economy-Legionville oil field. A few wells in this pool occur on the Walters and Ludwig farms just over the eastern edge of Harmony township. These appear to be located almost squarely in the shallow trough of the West Middletown syncline, though at a somewhat higher elevation on the sand than the wells on the anticlinal nose in the extreme southern part of this field. All these wells are said to produce from the Hundredfoot, which here carries more or less salt water.

Near the northeast corner of Harmony township a considerable gas pool has been developed in the trough of the West Middletown syncline. No data was secured regarding the producing sand in this pool, but it is believed to be either the Boulder or Fourth sand. Gas in the Boulder sand is found in limited quantities in this township without reference to structural features so much as to the quality of the sand. The northwest edge of the Fourth sand is somewhere near this area, and it is possible that a small pool of gas has collected near the edge in an open patch of this sand.

Craig oil and gas pool. This pool consists of less than a dozen small wells situated a mile northeast of the Davis pool. Practically all the oil and gas comes from the Boulder sand, which is here seldom more than 10 feet thick. Most, if not all the wells flow their oil with the escape of considerable gas. The wells were never large, and the total production of the pool is now only a few barrels per day. No salt water is found in the Boulder sand here. From the structural map (Plate VI) it will be noticed that this pool is apparently slightly west of the bottom of the Sewickley syncline at about the same elevation as the Boulder oil in the Davis pool. This pool is here encircled fairly well by unproductive wells which so far as could be learned found a poor Boulder sand with no water. The structural position of this pool is quite different from that in the Boulder sand in the Grubbs field described above, which is mentioned as being on the crest of the Brush Creek anticline. However, the actual elevation of the sand in the two pools shows a variation of less than 20 feet.

Cookson oil and gas pool. This pool is located in the central part of the township on or near the axis of the Crows Run anticline. The structure of the rocks in this vicinity has not been determined with as much accuracy as it has at some other points, but from the best information at hand the Hundredfoot sand which contains the oil appears to be folded into a rather steep, narrow arch which has a comparatively rapid pitch to the south. Oil and gas in the Cookson pool are confined entirely to the Hundredfoot sand, which in a number of wells carries no salt water. According to data furnished by Mr. George S. Reed, Baden, Pa., who as an oil producer is very familiar with this pool, many of the first wells here flowed heavily from a pay above the "break," while wells drilled at a later date filled up only a little way.

As is common in nearly all fields, the gas and oil had accumulated an enormous pressure before being tapped by the drill. This was rapidly reduced by subsequent wells. Water has been found with the oil in a number of these wells, but the proportion of it to oil is very small, being apparently much less than in the Crows Run field still higher up the anticline to the north. The Cookson pool is generally considered to be in a dry Hundredfoot sand. Most dry holes around the edges have found no water in this sand. The top of the pay streak is here from 0 to 10 feet below the top of the sand, and ranges from 1 to 8 or 10 feet in thickness. Little or no water and oil is found below the "break." The pool is now thoroughly developed, the new wells are all pumpers, and are down to a settled production. Here is another example of a pool in a comparatively dry sand, occupying the crest of an anticline with little or no water in the sand down the slope from the oil-bearing portion.

Crows Run oil pool. Well 388 on the Hammerle farm at the extreme southern end of this pool found a single 7-foot pay below the break, and 3 feet above the bottom of the Hundredfoot sand. Hammerle No. 5 (389) got an 8-foot pay at 1,517, a 6-foot one at 1,537, and another 3 feet thick at 1,550. The distances to the top and bottom of the sand were not preserved in the record. In 390, which is one foot lower on the sand, the pay begins in the top of the sand at a depth of 1,517 feet to within 5 feet of the bottom of the sand. In Hammerle No. 1 (387) there is only 8 feet of pay in the top of the sand. All these wells pump more or less salt water.

Near the southeast end of the pool the Hundredfoot sand is 55 feet thick, in the Hurst Heirs well (392) with a small pay 22 feet from the top of the sand. This had a slight show of oil. The Boulder sand in this well is 21 feet thick, with gas 2 and 7 feet from the top. The records of wells 398 and 399 show pays 48 and 46 feet respectively from the top of the sand. Well 400 got 10 feet of pay 21 feet in the sand, and the adjoining well (401) found it 11 feet thick, 22 feet from the top. Farther north on the Bock Heirs well 403 found some oil at 25 feet, and a better pay at 40 feet in the sand. In well 409, Bock Heirs No. 18, the Hundredfoot sand is 72 feet thick with two pays 5 and 48 feet respectively from the top. The pay streaks in the eastern part of the pool in this vicinity change quite rapidly from well to well, in one case the second pay streak, which is 40 or more feet from the top of the sand, changing from 25 to about 10 feet in thickness within 300 feet. In well 410 on the Concord church property the second pay is only 18 feet from the top of the sand In 411 this pay is 10 feet thick and 42 feet from the top. In the Mary Reed No 14 (414) 20 feet of pay occurs in the top of the Hundredfoot sand. This well had an initial capacity of 250 barrels per day. In well 415 the first pay was 13 feet thick, and 5 feet from the top of the sand. The top of the second pay is only one foot below.

This pool, though comparatively young, is now down to a settled production which in total is, however, still quite large. In a number of wells only a small proportion of water to oil is pumped; in others of equal capacity the amount of water is several times that of the oil. From what could be learned in the field there seems to be a general increase in the proportion of water to oil northward from the southern end of the pool, though specific facts on this point are not at hand.

Small pools of oil. About 1 mile north of Baden at well 383, several wells have produced small amounts of oil from the Hundredfoot sand on the Straube and Rosa Dunn farms. In Straube No. 2 (383) the Hundredfoot is given as 41 feet thick with 4 feet of pay near the bottom of the sand. No other records of wells in this pool could be located. Well 381 on the Ehrman (?) farm flows a small quantity of oil.

No pay streaks were found in the Aaron Wilson well (418). Though the Hundredfoot is 42 feet thick here it shows no white sand.

In the Chaney Heirs well (421) the Hundredfoot is 45 feet thick, but is "shelly" and gray with no white pay streak. In this well considerable gas was found associated with salt water in the salt or Butler gas sand. This is the only instance in this township where the Butler gas sand is reported in records as gas-bearing, though in many wells it is known to have made more or less gas when first tapped by the drill.

Mr. George C. Reed, of Baden, has kindly furnished a detailed record of the John Grazier gas well (382), which is given in full on page 44, and a section of it is also shown on Plate III. In this it will be seen that the Hundredfoot sand is only 27 feet thick, and carries gas. This sand is overlain by 15 feet of gray shale, above which is 1 foot of sandstone carrying gas. This indicates somewhat that the thin sandstone really represents the upper portion of the Hundredfoot sand farther east, and that the shale "break" has here thickened up to 15 feet at the expense of the upper sandstone member.

Prospective territory for new pools, in Economy township. This township has been carefully tested, and but very few places offer a fair inducement to producers for the expenditure of more money in wildcatting. Since most of the oil pools have been found along the crest of the Crows Run anticline, it is evident that all other indications being equal, preference should be given to locations within this more productive belt.

For this reason it seems that a well located a little east of north from well 376 in the Cookson pool, and about half-way between that well and 387, should get oil in the Hundredfoot if a pay can be found. It is doubtful that any wells producing from this territory will be large. Again, there is no structural reason why a well located 1,500 feet southeast of 388 should not get oil if the pay streak is found. If oil is found at this location the trend of development should be due north, and south to southwest. If this pay holds out, the productive portion should pass a short distance south of the dry hole south of 388.

It will be seen that these locations are meant to pick up the best chances of small extensions to Brush Creek and Cookson pools, and in these suggestions it is presumed that no holes have been put down in this territory other than those shown on the map. The writer knows that in many instances this presumption is not true, so he presupposes that prospective operators will look up all the details of a case thus pointed out before any expenditures are made, and to modify these conclusions to meet the facts as they are found upon closer investigations. It is assumed that the area northeast of well 390 and eastward toward No. 400 has been sufficiently tested to make it reasonably sure that no pay streaks are to be found in that area. The same may also be said of the small area northwest of the dry hole 385, and a short distance west of the producing area. Structural conditions are favorable for small extensions in those directions. If no wells have been drilled other than those shown on the map, there might also be found a small extension to the northeast of well 396. The small pool on the Straube and Rosa Dunn farm might be extended northeast along the strike of the rocks.

All other points within this township, so far as the writer's knowledge goes, stand about the same chance of being productive. With a good pay streak given, it is best to follow the structure in attempting extensions. Without the knowledge of where a good pay may be found, the testing of new territory is a gamble pure and simple.

New Sewickley and Dougherty townships, Beaver county. New Sewickley township lies north of Economy township and extends northward and westward beyond the boundary of the quadrangle, except for a very narrow strip along the northwest edge. This portion is in Dougherty township. Since it contains no geologic features of importance, this small area in Dougherty township will be discussed as a portion of New Sewickley township.

Within this area the dominant structural features are the Crows Run anticline, which crosses it from south to north, a little east of the middle, and the West Middletown syncline, which apparently dies out in the center of the New Sewickley township against the rapid rise of the rocks to the north. This rise is also quite rapid to the northwest from the trough of the syncline, but owing to scarcity of wells in this part of the township, and the fact that few records of the wells drilled have been preserved, the detailed mapping of this part from data on the Hundredfoot sand, is impossible. To add to the difficulties of securing a good map of the structure of the territory west of the Crows Run anticline, it was found that the horizon of the Ames limestone, upon which contours of the surface rocks are drawn, Plate V, is a hundred feet or more above the tops of the highest hills. This bed is present in outcrop at only one point west of Crows Run anticline. This is near the crest of Big Knob, at an average elevation of 1,280 feet above sea level. Well marked beds in the Lower Conemaugh and the Allegheny formations are found only along the deeper valleys, where the Kittanning coals are exposed. However, the contour lines as drawn on the map, Plate VI, show the general structural features with a fair degree of accuracy.

In New Sewickley township east of the Crows Run anticline, the structure is generally pretty accurate in the southeastern part, but from well 488 northward along the eastern edge of the township the data is scanty, and the contour lines which are drawn in sympathy with the facts farther to the west, may be considerably in horizontal error, though the general features of the structure are practically correct.

Crows Run oil pool. Only the northern part of this pool is in New Sewickley quadrangle, but this portion is the largest single oil-bearing area. As stated above, the southern half of this pool lies along the crest of the Crows Run anticline, but from the border of New Sewickley township northward the oil producing belt does not climb squarely up the steeply pitching axis of the anticline, but gradually swerves to the west of it, keeping more nearly on the strike of the sand, so that at the northern end of the pool the producing wells, though nearly 50 feet higher on the sand than at the southern border, are located at or near the shallow, pitching trough of the West Middletown syncline

The northern portion of the Crows Run pool is noted for its freakish pay streaks. In well 474 a pay in the top of the sand made 400 barrels per day, and in the next well to the south (475) 30 feet of pay made 200 or 300 barrels per day. Less than 200 feet east of this well, in No. 476, the record gives 16 feet of pay at the top of the sand, which produced only 2 barrels per day. It is said that this well was shot with 225 quarts of nitro-glycerine without materially increasing the production. The next well to the east of this was a dry hole, as was the one west of 475. Northward from 474, No. 473 had an initial production of only 9 barrels. The dates on which these wells came in are not known. It is possible that the sand in the vicinity of 474 had become partially drained, and the pressure greatly reduced before the others were drilled. Well 471 is said to have made over 100 barrels per day, while 472, not 40 feet away, got less than 6 barrels, and to the east not more than 200 feet away a well came in dry. Instances of such rapid changes in the thickness and porosity of the pay streaks are numerous in this pool, and the borders of the producing area are studded with dry holes. The John Blank well (470) found 10 feet of pay in the top of the sand, 469 got 11 feet, 468 16 feet, 467 12 feet, 466 24 feet, 465 7 feet, and 464, only a showing of pay in the top of a 76-foot sand. In a well on the C. R. Bonzo farm gas was found in the top of the Hundredfoot. These give a fair idea of the changes that take place in the pay streaks in this part of the pool. The entire production comes from a pay located at or near the top of the sand, though in a few wells a soft streak is found near the bottom.

From the point where the eastern border of the township cuts the northern boundary of the quadrangle, a more or less continuous belt of productive country has been developed to the southwest along the strike of the rocks for a distance of about 2 miles. This area is made up of a string of small pools in the Hundredfoot sand which are separated by patches in which the sand has no pay streaks. At the northern edge of the quadrangle well 442 on the Zeno Geohring farm shows 54 feet of white sand 25 feet below the top of the Hundredfoot, with oil 16 feet from the bottom of the white portion, and 63 feet from the top of the sand. The writer is not positive that the right record has been used for well 443. The one given is for Cookson No. 1, by the Bridgewater Gas Co. If this is the correct record for 443, the Hundredfoot here has a total thickness of 78 feet, with 3 feet of pebbly pay 20 feet from the top. In the D. H. Geohring well (447) the top of the pay is 27 feet in the sand, but in the same field the George Kline No. 1 well (452) got oil in the top of the sand.

In this field as well as in the Crows Run pool, most of the wells pump salt water with the oil. In all cases the presence of salt water seems to promote the productiveness of the sand. It doubtless has a tendency to prevent wells from parafining up, as those pumping water produce their normal amount much longer after being cleaned out than those that show no water. The general belief among operators throughout this part of the quadrangle is that a certain amount of salt water associated with the oil is very desirable. Many oil men have been led by experience to believe that the water and oil come out of the pay streak together, and hence must be very closely associated in that bed. In most wells the decrease in the production of salt water is similar to that noted in the Brush Creek field of Marshall township. When the salt water in such wells becomes exhausted, the production of oil soon ceases. As stated before, there are many reasons for believing that a large portion of the oil is here transported to the well from the pay streak by a moving body of salt water.

Very few indications of oil and gas have been found west and northwest of the West Middletown syncline. Half a mile southwest of Big Knob wells 434 and 435 on the Daniel Block farm got considerable quantities of oil from the Hundredfoot sand, but the pool was found to be very small, and the wells were soon exhausted. So far as the writer's knowledge goes, the western half of the township has shown no other indications of oil in the tests that have been made. The Hundredfoot sand is apparently of about the average thickness, though it becomes thin in places. It is, however, invariably reported as "shelly," blue, or hard, with few if any streaks of white sand in which, farther to the east, the pay streaks are found to occur. In well 432 on the David Lowrey farm the sand was 62 feet thick. The J. C. McCauley No. 1 well (430) is shown by the record to have about 80 feet of Hundredfoot, with a show of the Third sand. Well 429 on the Yeagan farm on the edge of Dougherty township is said to have had only a few feet of shells at the horizon of the Hundredfoot, while in well 424 on the M. Harvey farm 18 feet of Hundredfoot is reported.

Prospective oil and gas territory in New Sewickley township. This township offers few good opportunities for finding new pools of oil. The most prolific belt, which lies along the Crows Run anticline, is thoroughly tested, and drilling there will at best add only a few small producers as extensions to the present developments. East of this anticline probably the best show for a well is about half a mile due south of well 488 and on the eastern boundary of the township This is rather a poor chance, but if oil should be found, the trend of the development should be northeast and also northwest, to a point midway between wells 487 and 486.

West of the Crows Run anticline there seems to be little chance of getting good pools, for reasons given above. Also the structure of this portion could not be mapped with sufficient detail to admit of intelligent speculation as to where pools may occur. There are however ample untested areas in this part of the township to afford good size pools. Perhaps the best place for a test well is from one-half to three-fourths of a mile northwest of well No. 434. In fact if there have been no other wells drilled in the vicinity of this well than those shown on the map, a hole 1,000 feet due south of it might find some oil in the Hundredfoot. Without an intimate knowledge of the local conditions found in the wells that have been put down in this area, no detailed discussion of the relative value of the several areas that might produce oil will be attempted. It is intended that such question be left entirely to the judgment of producers, who are intimately acquainted with the prospecting that has already been done.

CRANBERRY AND JACKSON TOWNSHIPS, BUTLER COUNTY.

Cranberry township occupies the southwest corner of Butler county. It lies east of New Sewickley township, Beaver county, and north of Marshall township, Allegheny county. Only a narrow strip of Jackson township less than half a mile wide lies between Cranberry township and the northern boundary of the quadrangle, and since this area is geologically closely related to Cranberry township, the two will be discussed as one.

On the map, Plate VI, the trough of the Sewickley syncline is shown to enter Cranberry township from the south about 1 mile from the southwest corner. A short distance north of that point it branches into two synclinal folds, one of which continues the general notheast trend until it dies out against the Brush Creek anticline, off the northeast corner of the township. The other swerves northwestward for a short distance, thence northward to about the middle of the western border of the township. From this point the trend of the fold can not be made out from the data in hand. Wells 499 to 502 are doubtless situated not far from the axis, but a long and exhaustive search failed to secure a single record of these wells, and it is believed that they have not been preserved. It is thought from a study of the surface rocks that this fold gradually resumes its northeast-southwest trend, and leaves the quadrangle near the middle of the included portion of Jackson township, but these facts alone are not sufficient to justify the drawing of structural contours. Between the axes of these synclines the rocks rise steeply, forming the southern end of an anticline in the north central part of the township. This fold has a northeast-southwest trend and leaves the quadrangle less than a mile west of the eastern border of Jackson township. It apparently unites with the Brush Creek anticline a few miles farther north. Brush Creek anticline enters the southern border of Cranberry 1 mile west of the southeast corner and leaves the township 2½ miles north of that point.

Oil pools in these townships are confined almost entirely to the crests and flanks of the anticlines. Of these the Garvin and Ramsey pools are situated on the anticlinal nose described above. The Criders, Brush Creek, Hendersonville, and Peters pools are on the broad crest and well up the flanks of the Brush Creek anticline. The troughs of the synclines are signally free from pools of oil or gas, as are also the lower parts of the slopes.

Near the southwest corner of the township on the Charles Dumbaugh (?) farm, several wells (493) are said to have found oil in the Hundredfoot sand. Little information could be secured regarding the development of this pool. Some of the wells are said to have been very promising when first drilled in, but their production declined rapidly and the limited pool was soon practically exhausted. It is now producing a very small amount of oil per day.

Garvin oil pool. This pool was opened up in the early nineties, and many of the wells first drilled are now pulled and abandoned. Most of the oil was found on the Garvin, Meeder, Vandevort, Graham, Gardner, and Dumbaugh farms. It is said that a number of good oil wells were found to the east of the territory shown on the map as productive, but this portion of the pool is now abandoned and no data regarding it were secured. Many of the wells shown on the map have been drilled within the last ten or twelve years; some as late as 1904. Few of the records of wells in this pool give the initial production, but it is said that many of the earlier wells made from 100 to several hundred barrels per day, and the total output of the pool has been great.

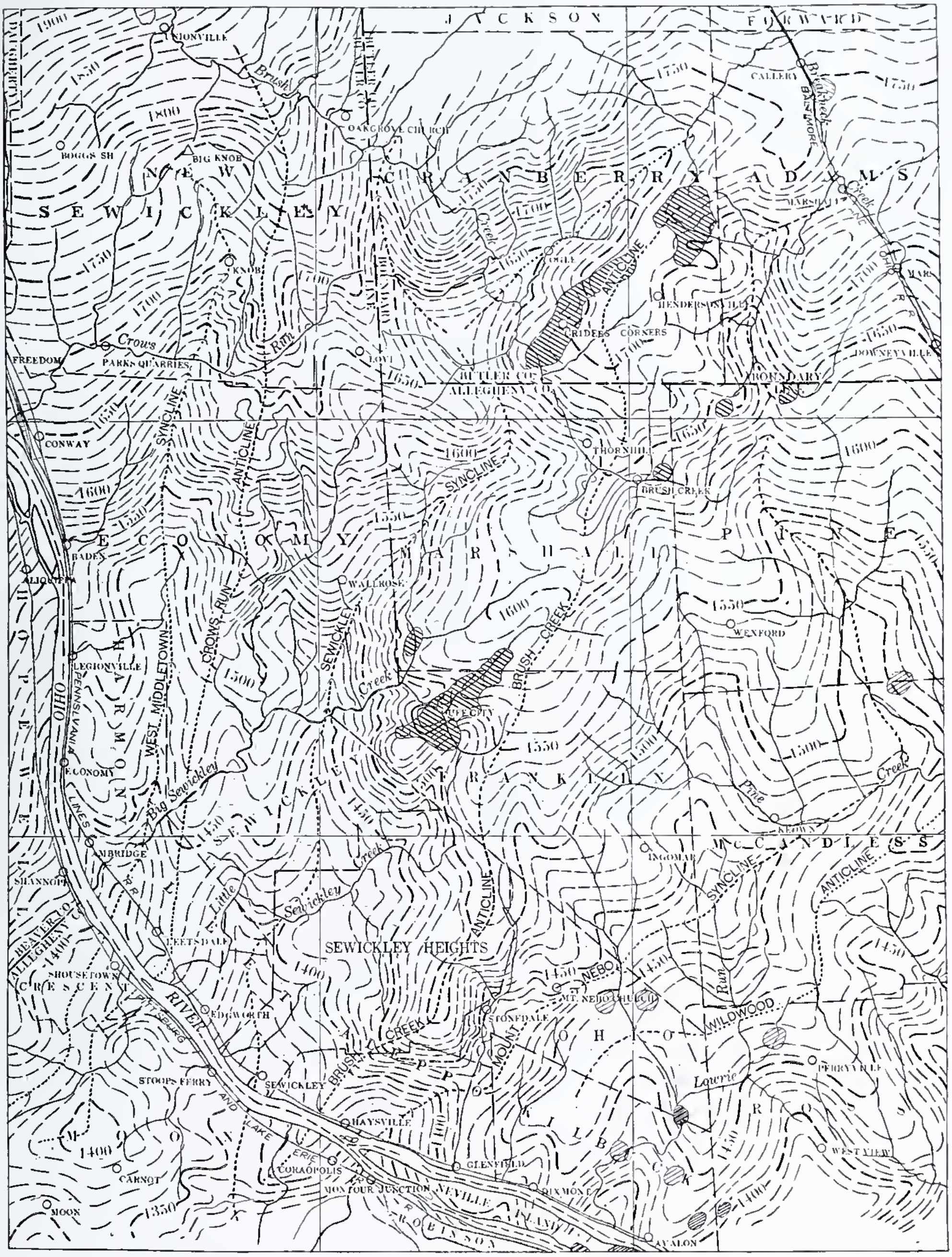
In this pool all oil comes from the Hundredfoot, which has a total thickness of from 80 to 130 feet. This sand is also water-bearing, the ratio of oil to water being about the same as that already described for the Brush Creek field of Marshall township, Allegheny county. This pool probably carries a greater proportion of water to oil than do the pools in New Sewickley township, and especially the Cookson pool, which is about 250 feet lower on the sand.

The principal pay streak in this pool is probably not the same as that of the Crows Run and Cookson pools, as in this pool it occurs at from 55 to 70 feet below the top of the sand. Well 503 has 31 feet of black sand at the top, with 36 feet of white sand below and 12 feet of pay at the bottom. Well 504 has 32 feet of black sand with 5 feet of white below to a 9-foot break of shale. The 6-foot pay streak occurs 10 feet below this break. This well also had a show of Snee, Boulder, and Third sands, but their thicknesses are not recorded. In the Newton Garvin No. 14 well (505) 8 feet of pay occurs 71 feet from the top of the sand. In 506 there is 12 feet of "clover seed" pay 54 feet from the top of the sand. It is 55 feet from the top in 508, and 58 in 509, where it is 23 feet thick and had an initial production of 35 barrels of oil to 40 of water. The ratio is now 1 of oil to 6 of water. In well 509 two pays were found, the first being 29 feet from the top of the sand and 8 feet thick, the second 56 feet from the top and 7 feet thick. The first pay in this well is apparently absent in the others mentioned, but probably corresponds to the white sand above the break in well 504. The second pay is probably the same as the one mentioned in the other wells, and it is from this pay, which is remarkably constant over the entire pool, that most of the oil has come. Well 510, which is the Frederick Meeder No. 9, drilled 2½ years after No. 509, at exactly the same elevation on the sand, had an initial production of 30 barrels of oil to 15 of water, in two pays 8 and 7 feet thick, and 29 and 56 feet respectively from the top of the sand. This well, however, now makes 1 barrel of oil to 10 of water. Variation in the amount of oil and water produced is still better shown by well 511, which is Meeder No. 1, drilled over 3 years before 510. In this well the pays are 8 and 5 feet thick, 61 and 85 feet from the top of the sand. No mention is made of the higher pay found 8 feet thick and 29 feet in the sand in well 510. Well 511 made 24 barrels of oil to 40 of water and now makes 8 times as much water as oil. So far as it goes, this fact tends to show that a considerable part of the water in the area later occupied by well 510 might have been drained out through 511 and 509 and other surrounding wells, before 510 was drilled, and that the oil originally in this area was not drained away in nearly the same ratio. This may not be true, however, because we do not know whether the ratio of water to oil is the same in the different pays, nor what effect the loss of the upper pay in 511 and the introduction of a lower pay might have on these ratios. However, it is possible that the pays are the same in all these wells, and that the apparent difference in depth to them in the sand is due to drillers recognizing different horizons as the top of the Hundredfoot. This possibility, as stated before, must be taken into account in all studies of these pay streaks.

Crider oil field. This oil field consists of two superimposed pools in the Hundredfoot and Snee sands. It occupies a narrow belt about one-fourth mile in width by about 2 miles in length, which lies to the west of and near the axis of the Brush Creek anticline. The trend of this belt is northeast-southwest, and the top of the Hundredfoot sand is between 35 and 40 feet higher at the northern end than it is at the southern. The pool in the Hundredfoot sand occupies only the northern third of the field, where it is said to carry more or less water with the oil. In well 516 on the J. Rowan farm, the pay in the Hundredfoot is 51 feet from what is given as the top of the sand. The thickness and capacity of the pay streak are not given. Oil was found in the top of the Snee sand in this well. On the same farm in well 517 the pay streak in the Hundredfoot is only 37 feet from the top of that bed. In this well, as in most of the others of the Crider field, the top of the Snee sand is oilbearing. In the Catherine Rice No. 1 well (518) the Hundredfoot carried no oil or water, and no pay streak is mentioned in the record. This well made 7½ barrels from the Snee. South and southwest from this point the Hundredfoot is unproductive and without visible water. In the Thomas Robinson No. 1 well (521) the Snee sand got oil 6 feet from the top of the sand. At the extreme southwest end of the pool in the Bertha Ulrich No. 1 well (522) 5 barrels of oil and no water were found 2 feet in the sand, and in an adjoining well (523) on the same farm, the Snee and Hundredfoot were both unproductive, but gas was found in the Boulder. This gas showed an initial closed or rock pressure of 250 pounds.

The reader's attention is again called to the fact that this field shows the same characteristics as other pools discussed. The oil apparently occurs on the crest and sides of an anticline in a dry sand, as well as in a wet one. Also the sand that produces oil and water together loses its oil and water at the same point going down the slope of the rocks, the existence of both in perceptible amounts being evidently due to the existence of a pay streak of a given porosity.

Brush Creek oil pool. A small portion of the northern end of the Brush Creek oil pool in the Hundredfoot sand crosses the southeastern corner of Cranberry township. In this area the Dutihl Heirs No. 5 well (524) got oil 4 feet and 47 feet from the top of the Hundredfoot in pays 2 feet and 10 feet thick respectively. Oil from the first pay was light. The initial production of the well was 10 barrels of oil to 60 of water. The proportion January 1, 1907, was 10 barrels of water to one of oil. A more or less complete barrier of unproductive sand seems to separate this part of the pool from that on the Nesbit and Garvin farms (wells 525 to 531) farther to the east. In well 525 the break in the Hundredfoot is noted 29 feet from the top. In 526 oil is noted 2 feet in the sand. In the B. Garvin No. 3



LOCATION OF KNOWN OIL AND GAS POOLS IN SNEE AND FIFTH SANDS

IN THE SEWICKLEY QUADRANGLE

▨	▨	▨	▨	▨
Gas in Fifth sand	Oil in Fifth sand	Oil and gas in Fifth sand	Oil in Snee sand	Gas in Snee sand

Contours are drawn on top of Hundred-foot sand which on this map may he considered to lie parallel to top of Snee and Fifth sand

Datum plane for contours 2000 feet below sea level. Numbers show distance in feet above this plane.

In areas where contours are not drawn the available data is not sufficient to admit of the delineation of the structure

well (527) gas and oil were found, 9 feet in the sand, with the top of the br [illegible] slate 14 feet below, but in Garvin No. 4, an adjoining well, the oil was found 3 feet above the break. So far as could be determined by a hurried examination of this pool, the same general water conditions prevail as have been mentioned for other parts of the pool, though in no records are the ratios of water to oil given.

Wells 532 to 535 inclusive are situated in what is locally termed the Hendersonville pool. But little data regarding these wells were secured. It is said that most of the wells get their oil in the Snee sand, but it is not known whether this is true. The only record secured of these wells is a partial one of 534 on the J. Gordon farm, which shows gas in the top of the Boulder sand. Structurally the pool is on the eastern side of the broad flat crest of the Brush Creek anticline. It is at a point favorable for oil in the Hundredfoot sand, as an extension of the western part of the Brush Creek field, and if the pays are good, the writer thinks that the Hundredfoot has also been productive in this area.

Duncan oil field. The portion of this field which is now producing lies about 1 mile northeast of Hendersonville on the Duncan, Boehm, McKinney, Marshall, Liese, and Goehring farms. The northern end of this field is on the axis of the Brush Creek anticline. The southern end extends a short distance down the eastern slope. The Hundredfoot, Snee, and Boulder sands are here oil-bearing. In Duncan No. 1 (536) the Snee now furnishes the production, though No. 2 on the same farm gets its oil from the Boulder, as does also well No. 538, on the Boehm farm. The T. M. Marshall No. 1 well (539) pumps from the Snee, but the writer does not know from what sand the gas comes in well (540) on the E. McKinney farm. In some of the wells of this group the Hundredfoot, Boulder, and Snee were all productive. The Joseph Goehring No. 1 well (541) had an initial production of 210 barrels of oil and 600 barrels of water from the Hundredfoot. This well came in June 3, 1893; in 1897 it was flooded by fresh water from a well that had been improperly plugged on an adjoining property. At this time it was making 10 barrels of oil and 150 barrels of water per day. This invasion of fresh water took place only in the Hundredfoot sand. The water apparently spread out in all directions from the poorly plugged well, but it traveled much more rapidly to the south and southwest, the rate decreasing with the distance covered. But very little evidence of value was secured regarding this interesting phenomenon. It is generally accepted as a fact that the water has traveled a distance of about 1 mile southwestward to the vicinity of Hendersonville, as at an average rate of about 500 feet per year the distances covered toward the north and west seem to be much less. From what could be learned in the field, producing wells in the Hundredfoot sand that lay in the path of this invading water increased rapidly in daily production for a few days or weeks before the fresh water made its appearance, after which they pumped fresh water exclusively. From this it would appear that practically all the oil and salt water contained in the pay streak were forced out ahead of the invading column of fresh water. In this area where the producing wells were of considerable size it is reasonable to suppose that if all the oil that would have eventually been pumped from those wells was in the pay streak at the time of the invasion of this fresh water, the accumulation of oil and salt water ahead of this fresh water after it had traveled for a mile would be enormous. The distance to which the fresh water can eventually penetrate depends upon the height and capacity of its head, the porosity of the invaded sand, and the degree of saturation of the surrounding areas by oil and salt water previously contained in the sand. These sets of forces tend to find an equilibrium, though as long as the oil and salt water are pumped from the sand in adjacent areas, and the supply of fresh water is constant, there will contiue to be a more or less rapid advance of the fresh water, but this water will continue to remain under a hydraulic condition so long as the total amount of fresh water coming into the oil sand per year remains the same.

If then the oil has been forced out of the pay ahead of the fresh water, the pool has simply been transferred from one spot to another, and possibly concentrated into smaller space under much higher pressure. In such cases wells in the path of the fresh water at a little less than a mile distant, should have shown a very much greater increase of oil and salt water than have been reported. In such a case it is reasonable to suppose that a well making say 10 barrels of oil and 100 of salt water, should quite rapidly increase to 100 or even 200 barrels of oil with a considerably less ratio of salt water. Since this has not been found to occur, it may be tentatively assumed that either the fresh water did not leach out a very large amount of the oil in the pay, or else this pay streak did not contain at the time of the invasion all the oil and salt water that would eventually have been pumped from a given well.

From a study of this and similar phenomena elsewhere, the writer doubts if all the oil was forced out of the pay streak when the invasion occurred. At the same time, in pools of the type common to the Hundredfoot sand of this quadrangle, there is a possibility that the total amount of oil to be produced from a given well is not all in the pay streak of that sand at any one time, and it is also possible that after the original head of oil and water has been pumped down in a pool, the oil and water as a more or less complete emulsion seep slowly into the soft porous stratum, not only from other parts of the sandstone, but also in some cases from the shale itself, the water originally coming from some associated water-bearing bed, and the oil from the shale through which the water is forced. This is merely one of several premises assumed by the writer to account for the accumulation of certain types of oil pools in this quadrangle.

The D. Hendrickson No. 1 well (542), situated near the northwest edge of the Duncan pool, got a little salt water 64 feet in the Hundredfoot, and a strong flow of gas at 100 feet from the top, with a strong flow of salt water 2 feet below. In this well some oil was found in the top of the Snee and a little gas in the Boulder. Between this point and the Garvin pool to the northwest, and the Ramsey pool to the north, the canoe-shaped trough of the Sewickley syncline has furnished no productive territory.

Ramsey oil pool. Most of this oil pool lies north of the quadrangle in Jackson and Forward townships. The production comes from the Hundredfoot sand, which is here from 80 to 95 feet thick. Mr. A. W. Hartzi, field superintendent for the South Penn Oil Company, who is thoroughly familiar with this pool, says that the oil and salt water comes from a pay below the break in this sand. He also says that as a rule, if a well does not pump a large amount of salt water, it does not produce much oil. When first drilled in, these wells filled up as much as a thousand feet from the bottom with oil and water, the height to which the fluid arose apparently depending upon the nature of the pay streak, and the degree of development of the pool, being highest in the first wells having the coarsest, loosest pay. Wells pumped down to a settled production and then left idle for a month or so, show practically no head of water and oil when started up again, and the daily production of oil and water is not materially increased by such a rest. When the water is exhausted in a well it ceases to make oil. Since only a few wells of this pool are within the quadrangle, a detailed discussion of it will not be made.

Prospective oil territory in Cranberry and Jackson townships. In these townships, as in those described above, it will be seen at a glance that the more favorable areas are at or near the tops of the anticlines.

By an examination of the map it will also be seen that these areas have apparently been thoroughly tested. The best chance of developing new territory seems to be that of finding small extensions to the developed pools. Such opportunities for getting wells are dependent upon local conditions found in individual wells and prospects of which the writer is not familiar. It is therefore better for the operator who is thoroughly familiar with the history of a given field to take such facts as are herein given and make his own locations. The geologic data are clearly expressed by the map and it needs no further interpretation to those familiar with this territory.

Adams and Forward townships, Butler county. Adams and Forward townships lie east of Cranberry and Jackson townships, respectively, and extend over the eastern and northern borders of the quadrangle, only a narrow strip of the southern part of Forward being within this area.

Notwithstanding the fact that a large number of holes have been put down in these townships, the structure of the Hundredfoot sand has not been mapped with as much accuracy as elsewhere on the quadrangle. This is due principally to the failure of the writer to secure sufficient information in the field regarding names and numbers of certain wells that then appeared to be unimportant, but have since been found to occupy strategic structural positions. Also, no records seem to have been preserved of a large number of wells similarly located to which levels were run. For these reasons the contours over the NE¼ of Adams township north of the Mars oil field are probably in considerable error, as are those in the southeastern part of this township. The writer is also not at all certain of the height of the axis of the Brush Creek anticline at the point where it crosses the western border of the township. It will be noted that a small pool of oil has been developed along the crest of the anticline at this point on the Lockwood, McKinney, and adjacent farms to the east. Levels were run to nearly all of these wells, but no records and few other data regarding them were obtained. It is to be regretted that the records of the Kline well (586) and the Blakely well (587) were not secured, also those of wells 572 to 575 inclusive. Since the contours on Plate VI were drawn, additional data secured too late to be incorporated in the map tend to show that the sand at well 575 is contoured 10 or 12 feet higher than it really is. The 1,700-foot contour probably extends a short distance north of this well.

Structural conditions. The Sewickley syncline and the Brush Creek anticline are the principal structural features of the township. The first enters the township from the south half a mile from the southwest corner, and extends northward as a narrow rather steep-sided, rapidly rising trough to the vicinity of well 571. From this point it apparently bends somewhat sharply to the northeast, narrowing and rising to the vicinity of well 375, beyond which it has not been traced, though it is believed to widen and flatten, the axis of the rapidly disappearing fold cutting the eastern border of the quadrangle about two miles from the northeast corner.

The axis of the Brush Creek anticline cuts the western border of Adams township near the middle, describes a broad curve to the east and north, and leaves the quadrangle half a mile from the western border of Forward township.

The only other structural feature of importance is a rather steep-sided anticlinal nose, east of the Mt. Nebo syncline, which enters the sheet from the east about midway between the north and south boundaries of Adams township, and extends southwestward to a point less than a mile west of Mars, where it apparently culminates in a flat dome. From this point it pitches abruptly southward, disappearing entirely a short distance south of the township.

Mars oil pool. This pool is located along the crest and southeast side of the anticlinal nose described above as east of the Mt. Nebo syncline. An almost continuous line of wells marks this pool from the Sarah Cote farm, about one mile southwest of Mars, northwest to a mile east of the quadrangle boundary. The production comes entirely from the Hundredfoot sand, which has a thickness here of from 90 to 130 feet. From one to four pay streaks are found. These apparently vary in position and thickness from well to well in much the same way as described in other pools. In the Sarah Cote well (560) the first pay was found 46 feet from the top of the sand, and the second pay 25 feet below. On the Nettie Campbell farm No. 3 well 561 had three pays 53, 69, and 80 feet respectively from the top of the Hundredfoot. In No. 2, located east of 560, a small pay was encountered 28 feet from the top, and another at 41 feet filled up the hole with 800 feet of water and oil. Two other pays at 58 and 62 feet made up the producing part of the sand in this well. In No. 1 on the Campbell farm, located west of well 561, the pays are given as 28, 34, 49, and 53 feet respectively from the top, the bottom pay being 24 feet thick. A peculiar fact noted in this well is that the third pay streak produces gas, while it is known that the second pay carries considerable salt water. The writer assumes that the second pay is above the "break," and the third below it. In the John Balfour No. 1 well (564) the Hundredfoot is 138 feet thick, and has two pays at 25 and 63 feet from the top. In No. 5 on the same farm (565) the pays are five and 85 feet respectively from the top. In well 567, Thomas Anderson No. 1, oil was found 30 and 70 feet from the top of the Hundredfoot, the second pay being 20 feet thick. In No. 2 on this farm the second pay is 80 feet from the top and 20 feet thick. Farther to the northeast well 580 on the Kennedy Heirs farm found oil at 11 feet and 42 feet in the sand. In 582, the pays were 27 and 72 feet from the top, and well 584 found two pays 11 and 75 feet respectively from the top. In Kennedy Heirs Nos. 4 and 9, the pays were found at 4, 26, 48, 59, and 81 feet in the former, and 6, 13, and 50 feet respectively in the latter. The other wells of this pool of which records are given, show practically as much variation in the location of the pay streaks. Unfortunately, few of these records show depth to the top of the shale "break" in the sand, and its thickness, but from what is given it appears that at least one persistent pay streak occurs above, and one below the break. If the break had been noted in all the records, the correlation of these pays would have been comparatively easy.

Within the Mars pool, the Snee and Boulder sands appear to be barren. The Third, Fourth, and Fifth sands are generally wanting, though in some few holes "shells" at the horizons of the Third and Fourth have been noted. No water, oil, or gas have been found in this pool below the Hundredfoot so far as could be ascertained

In well 562 on the H. W. Miller farm near Downieville, gas was found in the Thirtyfoot, but no details regarding the extent of this pool were learned.

It will be noted on the map that several gas wells (568, 572, 573, and 574) occur north of the Mars oil field in what appears to be the bottom of the Mt. Nebo syncline. Structurally this is a very rare location for a gas pool, and it can only be explained on such grounds by supposing that a slight cross anticline cuts the syncline with a southeast-northwest trend at this point, and that the rocks here dip both to the northeast and southwest. This explanation is strengthened by the fact that the anticlinal nose jutting out in this direction from the Brush Creek anticline to the northwest seems to pitch very rapidly toward this point. When detailed data are available regarding the producing sands in such pools as this, the explanation of their occurrence is usually much more evident. They are almost always found to exist in areas where the patches of pay streaks are small and irregular in shape. In this case no explanation is apparent.

Northward from the Mars oil pool no productive territory has been found until Evans City pool is reached, a few wells of which are shown near the northeast corner of the quadrangle. To the northwest, however, the Brush Creek anticline is marked by pools throughout most of its length across the townships.

In the small pool marked by wells 590 to 595 inclusive, the Hundredfoot sand is said to furnish the oil, though, as mentioned above, the records of none of these wells were found. Most of the wells in this pool have been abandoned, and it is said that at least a portion of them were drowned out by an invading body of fresh water, from some well that was improperly plugged. The extent of this drowned area was not learned. There seems to be a more or less complete break between this oil-bearing area in the Hundredfoot and that of the Callery pool farther to the north.

Callery oil pool. This pool is located to the west of the crest of the Brush Creek anticline, on a broad terrace which dips gently to the southwest toward the northern end of the Sewickley syncline. This is a comparatively young pool and a little drilling is still being done in cautious extensions to it. The field seems to have been developed from the south northward, as a number of wells at the southern edge have already been abandoned. No records of wells obtained in this field, however, give the data of drilling, and few give more than the distance to the top of the Hundredfoot sand and its thickness, and depth at which pays were found.

In some of these the distances from the top of the sand to top of the pays are as follows: well 587, 68 feet; well 588, 60 feet; John Staples No. 5, 61 feet, with 40 feet of pay; John Staples No. 7, 60 feet; well 602, 73 feet; 603, 68 feet, and 604, 66 feet. As a rule the pay sand in this pool is considerably thicker than it is found in the Hundredfoot pools already described, and many of the wells have been fine producers.

So far as could be learned, the water conditions in the Hundredfoot sand in this field are very similar to those already described for the sand in the Ramsey field a short distance to the northwest. The Butler gas sand in this field seems to invariably carry a large amount of water, as it doubtless does over most if not all of the quadrangle.

From the contours (Plate VI) it will be seen that the Callery pool and the Ramsey pool are closely related structurally. These pools are also closely associated with the Evans City pool most of which lies off the quadrangle to the northeast from the Callery pool. Wells 614 to 616 inclusive form a portion of the southern tier of wells in this pool, all of which get their oil from the Hundredfoot sand.

Prospective oil territory in Adams and Forward townships. This territory has been too thoroughly tested to furnish many new pools, and any new production found will be gotten in small extensions to developed pools. Considering the chances of finding a good pay equal in all parts of the township, the best show for a new pool is probably about half a mile southeast of well 596 in the western part of Adams township. This should have a fair chance for oil in either the Snee, Boulder, or Hundredfoot sands. There is no structural reason why this pool should not extend northeastward from the McKinney wells (593 to 595 inclusive) to join the southwestern part of the Callery pool. If the structural contours are fairly accurately drawn over the area east of Callery, a well located midway between wells 587, 609, and 614 would have something above an average show. Except for local extensions that are obvious from a study of the map, all other locations are of about equal value so far as structural conditions go.

THEORETICAL DISCUSSION OF THE ORIGIN AND MODE OF OCCURENCE OF OIL AND GAS IN THE APPALACHIAN FIELDS.

INTRODUCTION.

It is not within the scope of this paper to enter into a detailed presentation and discussion of the numerous theories advanced by geologists and others to account for the origin and mode of occurrence of petroleum and natural gas within what is known as the Appalachian fields. It is intended to select from each, however, such salient points bearing upon this problem as will present in brief the accumulated facts and conclusions on this subject to date, in order that the reader may have at hand a working basis from which he can get a clearer view of the scientific value of the facts set forth in the proceding pages. This reason must suffice for again forcing upon him a re-statement of arguments and data that have been quoted so frequently before by all of the recent writers on this subject. In making these quotations no attempt will be made to trace out and properly accredit to each author those ideas essentially his own.

SYNOPSIS OF PREVIOUS THEORIES.

ORIGIN.

Two general theories have been presented regarding the origin of petroleum and natural gas, viz, the organic and inorganic, both of which have had, and still have, many eminent supporters.

Inorganic. This is essentially a theory formulated by chemists. In 1866 Bertholet argued that petroleum had been produced by the action of water containing carbonic acid on alkali metals deeply buried in the earth, and hence highly heated. He found by experiment that when carbonic acid acts on hot alkali metals acetylides are formed and that these bodies when treated with vapor of water produce hydrocarbons resembling petroleum. In 1871, Byasson got practically the same results, and suggested that petroleum found in nature was produced by sea water containing carbonic acid or limestone in solution percolating deep into the earth and then acting on metallic iron or iron sulphide. In 1877 Mendelejeff, the great Russian chemist, strengthened this theory and argued that the interior of the earth contains metallic carbides, that is, metals, especially iron, combined with carbon; that water coming in contact with these highly heated carbides would start reactions which would produce hydrocarbons and convert the metals into oxides. Cloez in 1878 produced a liquid resembling petroleum by the action of hot water on the carbide of manganese, and also by the action of sulphuric acid on the carbides of iron and manganese. Since these experiments were made many chemists have produced practically the same results, and the fact has been established beyond a doubt that it is possible to make petroleum from inorganic compounds.

The work of these chemists shows that it is possible for such chemical compounds as petroleum and natural gas to be formed from the elements through natural processes within the earth's crust without the agency of either plant or animal life. This fact alone, however, does not prove that the great accumulations of these hydrocarbons found at different places throughout the rocks of the earth have originated in this way. An essential factor of this theory is enormous heat. In the Appalachian fields the great mass of data collected upon this point proves conclusively that the rocks from which petroleum and natural gas are obtained have not been subjected to the high temperature required by the inorganic theory. In this field these hydrocarbons are found in unaltered sedimentary rocks thousands of feet thick under conditions that to the geologist appear to have always rendered impossible the transfer, in any direction, of these compounds from igneous rocks. This view has, however, been questioned by Dr. David T. Day*(a)*, who suggests that such a migration of oil might have been made through capillary action in the close-grained shales of this region. This hypothesis will be referred to more fully under causes of accumulation.

Organic. Daubree treating wood with superheated steam produced a product that resembled petroleum. Warren and Storrer by the distillation of a soap made from Menhaden (fish) oil obtained several of the hydrocarbon groups found in petroleum. Engler made from Menhaden oil by distillation a series of oils among which was one compound "indistinguishable from commercial kerosene." Sadtler in 1897 distilled linseed oil under pressure and obtained a compound closely resembling petroleum. These experiments and hundreds of others have proven as conclusively that petroleum may be made artificially from animal as well as vegetable matter as the others

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(a) Trans. Am. Inst. Min. Eng., vol. 33, pp. 1053-1055, 1903.

have shown that it may be derived directly from the original elements which make up the earth's crust.

The belief that petroleum is derived from animal and vegetable matter has long been held by most geologists. Upon the exact way by which this transformation has been accomplished they are not so universally agreed. All admit, however, that the animal and vegetable matter or both from which the petroleum of the Applachian fields has been derived was deposited under the sea in the sedimentary rocks of that region at the time of their formation. It has been proven beyond question that the great body of sedimentary rocks of the Appalachian fields contain in the aggregate an enormous amount of petroleum and natural gas. Newberry states that from certain portions of the Ohio shales have been distilled as much as twenty gallons of petroleum to the ton. Hunt, Minchell, Lesley, Peckham, Orton, White, and others have collected data tending strongly to show that within this great mass of sedimentary rocks there is sealed up bituminous matter from which could be generated one to seven million barrels of petroleum to the square mile. In fact at all places where this shale has been examined it has been shown to contain from one-one hundredth to one-fifth of one per cent. of petroleum which may be obtained from it by destructive distillation at a comparatively low temperature. From data already in hand geologists are a unit in the belief that all the oil of the Appalachian fields has come from organic substances originally deposited with the sedimentary rocks of that region.

The nature of this organic material is still in doubt, but the preponderance of evidence now seems to favor attributing most of it to plant life which flourished in the Paleozoic seas at the time the rocks were deposited. Hunt, the Canadian geologist, advanced a consistent theory*(a)* in which he took the position that the larger portion of petroleum has been derived from animal life, the calcareous part of which now constitutes our limestone deposits. He further took the position that this petroleum was formed at the time when these rocks were deposited and was the result of primary decomposition of animal remains and is indigenous to the rock in which it is found. Another view is *(b)* "that petroleum is derived from the secondary decomposition of organic matter stored in the rocks. It supposes the original vegetable and animal matter to have suffered a partial transformation and to be now held in the rocks as a hydrocarbon compound from which by a *process of distillation* oil and gas are derived. The so-called bituminous shales are counted the chief source of these products. After distillation it is held that the gas and oil are mainly carried upward by *hydrostatic pressure* to some overlying porous stratum that serves as a reservoir." In discussing the origin of the "rock oils

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(a) { A. J. S. (2) 35, 168.
{ A. J. S. (12) 46, 361.

(b) Orton, Ohio Geol. Survey Report 6, p. 63.

of Ohio"*(a)* Newberry says: "The precise process by which petroleum is evolved from the carbonaceous matter contained in the rocks which furnish it is not yet fully known because we cannot in ordinary circumstances inspect it. We may fairly infer, however, *that it is a distillation* though generally performed at a low temperature." Again he says:*(b)* "The origin of the two hydrocarbons petroleum and gas is the same, and they are evolved simultaneously by the spontaneous distillation of carbonaceous rocks." In commenting upon this paper Orton*(c)* says: "Precisely what is meant by the term 'spontaneous distillation' in Newberry's theory is not easy to determine. * * * * He does not seem to require for oil production unusual temperature. He speaks of the distillation as 'constant' and as going on at a 'low temperature.' He never uses the term 'destructive distillation.' * * * * Destructive distillation is the heating of organic substances beyond the point of decomposition without access of air. What 'spontaneous distillation' is does not distinctly appear. If it can be shown that under the pressure of great depth and with the normal increase of temperature due to descent, the transformations in question can go on, then a basis is supplied for this phase of the distillation theory, but so far as known, there are no facts whatever to warrant the belief that such a state of things is true."

Peckham in the Tenth Census, Vol. 10, 1880, furnishes an admirable resumé of the literature on the origin of petroleum and natural gas up to that date. In conclusion he says: "These oils are undoubtedly distillates and of vegetable origin. The proof of this statement seems overwhelming. Pennsylvania petroleum was examined in 1865 by Warren and Storrer in this country and in 1863 by Pelouze and Cahours in France, who found the lighter portion to consist of a certain series of hydrocarbons identical with those obtained in the destructive distillation of coal, bituminous shale and wood when the operation was conducted at low temperatures. * * * * Again he says: "bitumens are not the product of the high temperatures and violent action of volcanoes, but of the slow and gentle changes at low temperatures due to metamorphic action upon strata buried at immense depths. * * * * The alteration due to the combined action of heat, steam and pressure that involved the formation of the Appalachian system from Point Gaspe in Canada to Lookout Mountain in Tennessee involving the Carboniferous and earlier strata, distorting and folding them, and converting the coal into anthracite, and the clays into crystalline schists, along their eastern border, could not have ceased to act westward along an arbitrary line, but must have gradually died out farther and farther from the surface. * * * *

(a) Ohio Agricultural Report, 1859.
(b) Ohio Geological Report, vol 1, p. 192.
(c) Ohio Geol. Survey, vol. 6, p. 68.

The great beds of shale and limestone containing fucoids, animal remains and *even indigenous petroleum,* must have been invaded by this heat action to a greater or less degree. * * * * If this hypothesis * * * * really represents the operation of nature, then we must seek the evidences of heat action at a depth far below the unaltered rocks in which the petroleum is now stored."

In commenting upon these statements Orton*(a)* says:

"How far below? If we descend 1,000 or 1,500 feet below the Berea grit, which is the great repository of oil and gas in eastern Ohio, we reach the bottom (on an average) of the Ohio shale, and this is the only source that we know in our series of oil and gas of the Pennsylvania type. But the drill has repeatedly gone down 1,000 or 1,500 feet below the Berea Grit, and not a trace or hint of metamorphic action is found in the drillings that are brought up. In such drillings from the deep well at Canal Dover, 2,700 feet below the surface, and even 1,800 feet below the Berea Grit, the microscopic spores that make so characteristic a feature of the black shales were found in normal condition. All observations attest not only the general uniformity of the shale formation throughout the state and at all depths, but also the entire absence of any appearance of metamorphic action.

"The same line of facts obtains in regard to the limestones underneath the shales. They have been penetrated to a great depth. The drill in the well of the Cleveland rolling-mill rested at 3,200 feet below the surface, but the limestones at the bottom of the hole showed no signs whatever of metamorphism. The same is true of all the deep borings of northwestern Ohio. Nearly the whole of the Lower Silurian system has been penetrated there, and new supplies of oil and gas are found in these rocks, but they obviously come from the limestone themselves, and differ in a marked degree from the oil and gas of the shales. In Canada the Trenton limestone bears oil where it is separated by only a stratum of sandstone from the old granite floor of the continent.

"But in the second place, Peckham demands for oil-production slow and gentle changes at low temperature." We must again ask for a limit. How low a temperature? Must it not be high enough to agree with the facts of observation and experiment as to the production of gas and oil by the destructive distillation of the bituminous shales? The temperature at which such changes are effected in the laboratory will scarcely be placed below 400 degrees Fahr. But the shales could not be brought to this degree without suffering metamorphic change. They contain alkaline solutions in greater or less amount, and both Bischof and Hunt have shown that when such compounds are present, they become powerful solvents of silica and silicates at as low a temperature as 212 degrees Fahr. If, then, the temperature had been raised to even 212 degrees Fahr., there would have been unmistakable evidences of the fact left in the constitution of the rocks.

"But if a lower temperature is proposed than that which we are obliged to use in effecting destructive distillation in the laboratory, we are compelled to ask, on what authority? It is of no use to answer that we do not know at how low temperatures this distillation can be accomplished in nature. This is true, but it is none the less

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(a) Geol. Survey of Ohio, vol. 6, pp. 72-73.

true that if we reason upon the subject at all, we must be goverened by the facts that our experience affords. Any other way of reaching an answer is assumption, pure and simple.

"In the third place, this theory would seem to necessitate a coke or carbonized residue in the rocks which give rise to the petroleum. Inability to point out such a residue seems to have been one of the reasons that led our author to locate the source of the oil-distilling heat at such great depth. He counts a carbon residue a necessity, but he buries the rock from which the petroleum is derived so deep that we cannot expect to obtain any direct knowledge of it. As has already been shown, in doing this, he drops below the only known source of oil and gas of the Pennsylvania type.

"The absence of these residual products constitute a real difficulty in the way of any distillation theory.

"On the whole, then, we are obliged to conclude that Peckham's theory does not harmonize with the facts of Ohio geology, and that it cannot be used to explain the origin of the substances whose history we are seeking to trace. * * * *

"Why the phenomena of oil-production have been generally reported from shales, and not from sandstones, has not been explained. The difference between the two formations in this respect may be, in part, due to the fact that the shale seals up the vegetable matter more perfectly than the sandstone. In the latter, ordinary decomposition would seem to have a better chance to go on.

"If petroleum, arising from such springs as occur in Central and South America, had found its way by rivers to lakes or seas, or had been liberated from sources beneath the sea, the same results would have followed. It would have been absorbed by the fine particles of clay held in suspension in river and sea, and the combined clay and oil would have been gradually carried downward to rest on the sea floor, an oil-bearing shale. * * * *

"In these seas, as we know, there was a vast development of marine vegetation. Some plants of rhizocarpean affinities were especially abundant and their resinous spores and spore cases, which constituted by far the most durable portions of the plants, were set free in enormous quantities. Even now, in some parts of the series, these spores constitute a notable percentage of the shale. In structure and composition, they are but little changed from their original condition. Other portions of this and like vegetation may have been carried to the sea-floor in a macerated condition and have there passed through the coaly transformation, resulting in the structureless, carbonaceous matter that constantly characterizes the black shales. This carbonaceous substance can stilll be made to yield the members of the bitumen series through the agency of destructive distillation, and, doubtless, so also can the spores that remain unaltered in the shales, both leaving a carbon residue thereafter.

"Gas and oil have been considered together in all the preceding discussions, as if the history of one would cover the history of the other also. There are, however, speculations which dissociate them in origin. By some, gas is counted the first and original product, and it is supposed to be converted into petroleum in the sandstone reservoirs by some unknown process of condensation.

"This question, like those that have preceded it, does not admit of a final and definite answer at the present time, but the chemical probabilities do not seem to favor this view. Petroleum is more composite and unstable than gas, and in these respects it seems to stand at less remove from the organic world than the latter. A large percentage of natural gas is light carburetted hydrogen, one of the simplest and most stable products of decomposition. Petroleum readily gives rise to marsh gas when subjected to destructive agencies, but we have no known experience in which the higher compound results from synthesis of the lower. It seems, therefore, safe to count petroleum first in the order of nature."

In summing up this discussion he says:

" * * * a few of the previously stated propositions in regard to the origin of petroleum that seem best supported, will be repeated in concise terms:

"1. Petroleum is derived from organic matter.

"2. It is much more largely derived from vegetable than from animal substances.

"3. Petroleum of the Pennsylvania type is derived from the organic matter of bituminous shales, and is of vegetable origin.

"4. Petroleum of the Canada type is derived from limestones, and is probably of animal origin.

"5. Petroleum has been produced at normal rock temperatures (in Ohio fields), and is not a product of destructive distillation of bituminous shales.

"6. The stock of petroleum in the rocks is already practically complete."

From the above statement it will be seen that while Dr. Orton believed that these hydrocarbon compounds are derived from vegetable and animal origin, at low temperatures without destructive distillation, he does not offer a definite explanation of how this transformation took place. Dr. Charles B. Morrey, of the Ohio State University, fills this gap in Dr. Orton's observations as follows:

"In accounting for the origin of oil and gas from organic matter, geologists have been unable to furnish the agent which might have brought about the proper decomposition, since there is no evidence of the action of heat on the vegetable and animal remains in Ohio fields at least.

"Now the only other agent with which we are acquainted which can produce the same compounds as we have in destructive distillation of organic matter are *Bacteria*. These organisms acting in the absence of air—i. e., under water—produce from vegetable matter marsh gas, olefiant gas and other hydrocarbons as well, a process frequently shown by experiment and occurring in very sluggish streams, marshes or bogs at the present time. The compounds produced here partly escape into the air and are in part retained in the mud, as a simple stirring of this shows, and there is abundant reason for believing that this same process has been going on for ages past. B. Renault has found bacteria in fossil remains of various epochs—Jurassic, Permian, Carboniferous and Devonian.

"In the formation of shales by stream deposits, wave action, and ocean currents, quantities of organic matter, largely vegetable, were deposited in the mud giving rise to such shales, and along with this material, bacteria in enormous numbers. These bacteria acting in the absence of air would form marsh gas and heavier hydrocarbons just as takes place today. This decomposition could go on not only in shallow water but also at great depths, as experiments have shown that the action of bacteria is not prevented by a water pressure of 600 atmospheres corresponding to a depth of more than 15,000 feet of water. Bacterial decomposition would continue until all the organic matter was broken up into compounds no longer capable of being attacked—the hydrocarbons among others—or until the bacteria were killed by an accumulation of their own products. In the latter case we should probably find a much higher percentage of carbon as in coal, than we have in oil or gas. Or the decomposition could also have been stopped by a drying out of the shales—the presence of a certain amount of water being necessary for bacterial growth. Where animal remains in larger quantities were decomposed, we would have not only the hydrocarbons, but also various nitrogen and sulphur compounds exactly as we find in limestone oils.

"So that I should say that petroleum of the Pennsylvania type and gas in similar situations were formed in the mud of which shales were composed, from the time the mud was first deposited and by the decompositing action of bacteria on the organic matter therein, and the formation continued until bacterial action was stopped in the ways above mentioned.

"In the case of limestone oils and gas, the bacterial decomposition would begin with the deposit of the first dead organism, so that these substances have arisen in such localities by the action of bacteria on the soft parts of those animals whose hard parts form the limestone.

"Whether there is still undecomposed organic matter in shales, limestone, etc., experiment alone can determine; probably not, however.

"Doubtless enormous quantities of gas and oil formed in the way above described escaped into the air and were lost, and what remained was retained in various mechanical ways which it is not my province to discuss.

"My reasons for believing that oil and gas have arisen in this way may be summarized as follows:

1. Bacteria produce just these decompositions when acting in the absence of air.
2. Bacteria were present in the formations along with other organic matter.
3. Bacteria are the only agents known which can produce such decompositions except heat.
4. The action of heat (in the Ohio fields at least) is excluded by geologic evidence."

This phase of the subject is touched upon by David White *(a)* in discussing certain oil-bearing shales of Wisconsin of which he says:

"The shales, known as Plattville shales, of lower Ordovician (Black River) age, lie at the base of the Galena limestone, regarded by Ulrich as Trenton. They occur in irregular patches scattered over an area of nearly 2,000 square miles. The oil shales embrace thin black shales and thicker chocolate, to buff shales mingled with calcarous sediments and containing occasional marine invertebrate remains. The

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(a) Science, vol. 23, No. 595, pp. 814-817, 1906.

approximate analysis is reported to show a loss of volatile of 21 per cent. from air-dried material, with an additional loss of about eight per cent. by incineration. The rock yields a very porous light oil, 1.98 in specific gravity, giving gas bubles in water. * * * *

"Thin sections of the light chocolate shales show them to contain minute, flattened, generally oval and discoid, translucent bodies of a brilliant lemon-yellow color, and highly refractive. * * * These yellow bodies * * * are, in vertical section, seen to lie horizontally matted with other sediments, and crystals of later formation, precisely like the matting of forest leaves beneath the winter snow. While varying greatly in size, they accommodate themselves topographically when overlapping or surmounting the coarser rock material, and seem to preserve their individuality even when apparently in contact. They are incredibly numerous, constituting over 90 per cent. of the rock mass in the richest layers. * * * The yellow bodies are, therefore, interpreted as the fossil remains of microscopical, unicellular, gelosic algae, apparently comparable to the living Protococcales. They appear to have been somewhat enriched in bitumen after the cessation of bacterial disintegration, which, in the buff shales, does not seem to have progressed sufficiently to form a noticeable fundamental jelly. * * * The dark brown ground mass appears to consist of a fundamental jelly, largely filled with minute mineral matter and granulose fragmental debris or wreckage due to destructive bacterial action on the gelosic bodies, many of which, like the small fragments of larger forms of associated algae, are greatly corroded. Many of the gelosic bodies were doubtless completely decomposed. To this bacterial work on the organisms is due, in the judgment of the author, the essential character of the somewhat humified, fundamental jelly itself, to which there has probably been accession of attracted bitumen.

"The oil shales owe their volatile hydrocarbon contents either directly or indirectly to the fossilized gelosic residues of microscopical organisms regarded as algae, which locally compose over 90 per cent. of the sedimentary material. These pelagic or floating algae fell in prolonged showers in quiet or protected areas where the water was presumably somewhat charged with tannic or humic solutions conducive to the arrest of anaerobic bacterial decomposition. Possibly the bacterial action as arrested by its own products. The original deposits were doubtless several times as thick as those now remaining, since it is probable that the organic residue represents as little as one-twelfth of the original volume.

"The Ordovician, like the Carboniferous gelosic algae, appear to have exercised an attractive or elective influence on bituminous compounds, particularly those of illuminent values, and to have consequently been permanently somewhat enriched. * * *

"The gelosic bodies found in the Ordovician oil shales * * * * offer an hypothesis which it is believed will prove satisfactory, though subject to conditional modifications, in explanation of the origin of the oil and gas in rocks of Paleozonic age in other basins. There can be no doubt that similar organisms swarmed in other parts of the same sea or other seas, and that, whether or not they have been recognizably preserved as in the light chocolate shales near Platteville, they have contributed enormously to the hydrocarbon contents of their respective formations."

There is at present little doubt among geologists that most of the oil and gas found in the Appalachian fields has originally come from animal and vegetal matter imbedded in the rocks of that region at the time of their disposition, and they are more and more coming to believe that the transformation of this matter into petroleum and natural gas has been in a large measure accomplished through the action of bacteria under water, and therefore in the absence of air.

CAUSES OF ACCUMULATION.

Coincident with the development of theories regarding the origin of petroleum and natural gas, others were presented by geologists to account for the presence of the great pools of these hydrocarbons found under enormous pressure in deeply buried rocks throughout the Appalachian region. Among the first of these theories was one by Prof. John S. Newberry who believed that the oil and gas had been collected from below by hydrostatic pressure. Dr. T. Sterry Hunt in 1862 argued that the oil found in limestones of southwestern Ohio, Canada, Illinois, etc., had been formed from animal or plant life in the same rock strata now yielding the oil, the decomposition having taken place under such conditions that the organism passed directly into petroleum which has since remained in the rocks where it was formed. Both of these writers believed that the oil and gas found in pools had collected in these spots through geologic agencies after it had been formed, and at an early date they laid down the fundamental principles of the Structural or Anticlinal Theory to account for this movement.

Anticlinal Theory.

Though the principles of the Anticlinal Theory had been advanced as early as 1859, Dr. I. C. White made the first practical application of them in 1882-83, during which time he pointed out the location of several important gas fields in Pennsylvania and West Virginia. From these results he formulated and published in 1885*(a)* an outline of the Anticlinal Theory in which he laid special emphasis on the paramount importance of structure as a factor in gas accumulation. He sums up his conclusions as follows:

"But while we can state with confidence that all great gas wells are found on the anticlinal axes, the converse of this is not true, viz.: that great gas wells may be found on all anticlinals. In a theory of this kind, the limitations become quite as important as, or even more so than the theory itself; and hence I have given considerable thought to this side of the question, having formulated them into three or four general rules (which include practically all the limitations

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(a) The Geology of Natural Gas. Science, June 26, 1885.
Reprint W. Va. Geol. Survey, vol. I (a) pp. 51-52.

known to me, up to the present time, that should be placed on the statement that large gas wells may be obtained on anticlinal folds), viz.:

(a) The arch in the rocks must be one of considerable magnitude.

(b) A coarse or porous sandstone of considerable thickness or, if a fine-grained rock, one that would have extensive fissures, and thus in either case rendered capable of acting as a reservoir for the gas, must underlie the surface at a depth of several hundred feet (500 to 2,500).

(c) Probably very few or none of the grand arches along the mountain ranges will be found holding gas in large quantity, since in such cases the disturbance of the stratification has been so profound that all the natural gas generated in the past would long ago have escaped into the air through fissures that traverse all the beds.

(d) Another limitation might possibly be added, which would confine the areas where great gas flows may be obtained to those underlain by a considerable thickness of bituminous shale.

(e) Very fair gas wells may also be obtained for a considerable distance down the slopes from the crests of the anticlinals, provided the dip be sufficiently rapid, and especially if it be irregular or interrupted with slight crumples. And even in regions where there are no well marked anticlinals, if the dip be somewhat rapid and irregular, rather large gas wells may occasionally be found, if all other conditions are favorable.

"The reason why natural gas should collect under the arches of the rocks is sufficiently plain, from a consideration of its volatile nature. Then, too, the extensive fissuring of the rock, which appears necessary to form a capacious reservoir for a large gas well, would take place more readily along the anticlinals where the tension in bending would be greatest."

In 1892 he published an article on the Mannington oil field and the history of its development,*(a)* in which he applies the principles of this theory in the location of oil pools as follows:

"My working hypothesis was that since the gas pressure is due to a column of water, and since this must be practically the same for any limited area where the rock lies at the same depth below sea level, the oil deposit in this particular rock must extend across the country along the strike of the beds, in a pool comparable to the surface of a lake or a chain of small lakes, if the rock reservoir should not be equally porous everywhere along the strike. Hence, if my theory is true, it would only be necessary to follow the strike of any particular coal bed, limestone, or other stratum outcropping where the oil was actually developed in order to trace the course of the oil belt upon the surface, and thus to determine with approximate accuracy, many miles in advance of the drill, the location and width of such possible oil territory."

Since the publication of Dr. White's paper in 1885, the Anticlinal Theory has been sujected to numerous expansions and modifications by different geologists studying various portions of the Appalachian

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(a) Geological Society of America, vol. III, pp. 187-216, April 15, 1892. Reprint W. Va. Geol. Survey, vol I (a) pp. 55-56.

fields. In the following quotation from Griswold*(b)* is given in full what is perhaps the latest and most elaborate statement of this theory:

"Whether the petroleum comes from within or from below the shales, it must pass through them, and to do this it must pass through the very small pores existing in those relatively impervious beds. The nature and cause of this movement is not understood. Capillary action and great rock pressure may be suggested as causes which aid in forcing the petroleum out from the shales, but there are not sufficient data on this subject to justify any scientific explanation. It matters little what is the ultimate source of the oil; the important facts are its occurrence now in the porous sandstones, its circulation through the rocks, and the conditions leading to its accumulation in commercial deposits.

"*Movement in porous rocks.* The porous rocks into which the oil and gas enter may be dry, or they may be completely saturated with water. In most cases it is probable that a combination of these two conditions exists—that the porous rocks are completely saturated with water up to a certain level, but above that point they are dry. The movement of the hydrocarbons through the rocks will not be the same in the two cases, and therefore each condition must be considered separately.

"If small quantities of oil and gas enter a dry porous rock at different points the oil will flow down as long as gravity is sufficient to overcome the friction and the capillary attraction. The gas will diffuse with the air or water vapor contained in the pores of the rock.

"Oil and gas entering a porous rock that is completely saturated with water will be forced up to the top of the porous stratum by the difference in the specific gravity of the hydrocarbons and the water. Here the oil and gas will remain if the porous stratum be perfectly level, but if it has a dip sufficient to overcome the friction, the particles of oil and gas will gradually move up this slope, the gas with its lower specific gravity occupying the higher places.

"In case the porous rocks are partly saturated a combination of these two actions will take place. The oil entering above the line of complete saturation will flow down to that line, and the oil entering below will be forced up to the top of the completely saturated portion.

"The statements given above are based on the assumption that the oil-bearing rock is homogeneous throughout and that the oil will move with the same degree of freedom in every direction. This is rarely the case. Sandstones are noted for their irregularity in composition, as regards both the size of the individual grains of sand and also the material which cements the grains together. It is obvious that any fluid will move more rapidly through a coarse conglomerate imperfectly cemented than through a dense, fine-grained sandstone, the particles of which are thoroughly coated, and all the interstices filled, with impervious cement. If the oil-bearing rock contains areas practically imperivous, these areas, according to their size and position, will be more or less perfect barriers against the movement of the oil or the gas.

(b) U. S. Geol. Survey Bull. 318.

"*Places of accumulation.* (1) In dry rocks the principal points of accumulation of oil will be at or near the bottom of the synclines or at the lowest point of the porous medium, or at any point where the slope of the rock is not sufficient to overcome the friction, such as structural terraces or benches. (2) In porous rocks completely saturated the accumulation of both oil and gas will be in the anticlines or along level portions of the structure. Where the area of porous rocks is limited the accumulation will occur at the highest point of the porous medium, and where areas of impervious rocks exist in a generally porous stratum the accumulation will take place below such impervious stop, which is really the top limit of the porous rock. (3) In porous rocks that are only partly filled with water, the oil accumulates at the upper limit of the saturated area. This limit of saturation traces a level line around the sides of each structural basin, but the height of this line may vary greatly in adjacent basins and in different sands of the same basin.

"Partial saturation is the condition most generally found, in which case accumulations of oil may occur anywhere with reference to the geologic structure; it is most likely, however, to occur upon terraces or levels, as these places are favorable to accumulation in both dry and saturated rocks.

"Under all conditions the most probable locations for the accumulation of gas are on the crests of the anticline. Small folds along the side of a syncline may hold a supply of gas, or the rocks may be so dense that gas can not travel to the anticline, but will remain in volume close to the oil."

This is, however, but a restatement and elaboration of the theories advanced by the older geologists as regards the part water plays in the work of accumulation, and is based, as were the others, on the idea that water acts as a transporting agent through difference in specific gravity alone. In this statement Griswold fails to insert a point made by Blatchley*(a)* regarding oil deposits of the Trenton limestone in Indiana, who in favoring moving water as the agent of accumulation says:

"The water when it first passed into the Trenton rock gathered the particles of disseminated oil upon its surface and then pushed them ahead into the higher and limited areas in which the great accumulations are now found"

This point was also stated by Hoeing in 1904, (*b*) as follows:

"The salt water is the direct agent through which the accumulations of oil and gas have taken place. With a given rock containing oil scattered through its mass the salt water in the same rock rising up the dip collects the oil as it rises, the latter by its lighter gravity then separating from the water and rising ahead of it, in volume increasing in proportion to the distance along the dip through which it rises, finally being caught and held in some structural fold in the rock; but (and this is an important modification of the anticlinal theory) only rising far enough up the dip to keep ahead of the salt

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(*a*) 21st Ann. Rept. Ind. Dept. of Geol. 1896. pp. 45-

(*b*) The oil and gas sands of Kentucky, Bull. No. 1, p. 22.

water so that the position of the oil with reference to the summit of the fold may be predetermined by the height to which the salt water can rise."

Aside from these two exceptions, the general idea seems to be that the Anticlinal Theory requires for the formation of an oil or gas pool the following conditions:

(1) A source of oil and gas.
(2) A sufficiently porous rock to act as a reservoir.
(3) An impervious cover for the reservoir rock.
(4) Slight, irregular folding of beds.

These are considered the four necessary conditions. In addition, one of the following important factors is thought to *affect the location* of every oil pool:

(1) Dry rocks.
(2) Rocks that are dry in places, and saturated with water in adjoining areas.
(3) Rocks saturated with water.

With these conditions satisfied in a region, the following results must by this theory inevitably follow:

(a) If the rocks are dry, the gas pool will form in the porous bed along the axes of anticlines (preferably domes) and at the edges of flat areas, from which the rocks dip. Oil pools will collect in the porous bed in the synclines (preferably basins), or at the foot of slopes bordering flat areas.

(b) If the rocks are partly saturated with water and partly dry, the gas will collect as in (a). The oil will accumulate immediately above the water in contact with it.

(c) If the rocks are saturated with water the gas will accumulate, as in (a). The oil will collect in the porous bed below and in contact with the gas, and the salt water will be below and in contact with the oil.

Therefore, in areas having the proper structure, the only reasons why accumulations are not found at the strategic points, or why they occur at other points, are:

(1) No source of oil or gas.
(2) Lack of sufficient porosity in the reservoir rock.
(3) Lack of impervious cover for the reservoir rock.

According to the Anticlinal Theory as it stands approved today, the above stated conditions should govern the position of every oil and gas pool in the Appalachian fields, and should as consistently account for the failure of favorable structural areas to furnish their due share of oil and gas. With this view of the subject the writer can not entirely agree, since many of the facts secured in the examination of the oil and gas fields of the Sewickley quadrangle do not coincide with its teachings. The fundamental structural idea of the Anticlinal Theory holds good, but the deductions made from that principle, as given above, are too limited in their scope to be of universal application in the Appalachian fields.

Application of the Anticlinal Theory in explaining the location of the oil and gas pools of the Sewickley quadrangle.

A glance at Plate VI reveals the fact that 90 per cent. or more of the oil producing territory of the Hundredfoot sand is situated at or near the axis of the anticlines or at least well up the slopes from the bottom of the synclines.

Though salt water has invariably been found associated with the oil in these pools, it is nearly always in limited quantities, and confined entirely to the thin porous patches of pay streaks. The supply of both oil and water are coexistent and both are usually exhausted together. The head of water and oil in a well, as well as the ratio of water to oil, is not influenced by structure, as many of the driest pools are located down the slope of the continuous sandstone stratum from pools that produce a much greater ratio of water to oil, with no perceptible difference in the quality of the pay streak from which the water and oil come. Outside the productive areas, the sand is usually found to be harder and closer, with no show of oil, gas, or water. If this sand is to be considered unsaturated where no water is detected by the drill, it is difficult to understand how, by the Anticlinal Theory, immense pools of oil and water could have been collected under high pressure in thin lenses of pay in a close, hard sandstone on the tops of anticlines. If the sandstone is saturated, holes around the edges of pools should show water in the pay streaks which in many cases they do not. Also most of the oil should be found in the topmost pay. If by the Anticlinal Theory this oil has succeeded in climbing up the slope of the anticline (with an average dip of less than 1 foot to 50 feet) through the closer, harder sandstone from one lens of pay to another, it seems reasonable to suppose that its ultimate point of rest would be in the highest pay streak of the sand at the crests of the anticlines. Also if the highest pay streak be of equal thickness and porosity to the lower pays, at a given point, and the whole bed is saturated with oil and water, this pay should therefore carry the greatest ratio of oil to water, and where several pays in the same sand carry oil, the topmost one should furnish oil exclusively. This is in no sense true. In numerous instances wells have been known to carry oil and water in as many as four distinct pay streaks, which according to data collected from men in the field, show no perceptible preference for oil in the uppermost pay. In fact, the lower pays in many wells apparently show a much greater ratio of oil to water than the top one. Unfortunately this point is not explicitly pointed out in records of wells, so it is supported only by hearsay data. However, the writer is satisfied that it is in the main true. Again, if we consider its enormous quantity and high pressure, we can not reasonably assume that the oil in the thin pay streaks of loose white sand is indigenous. If it is not indigenous, this oil must have reached the porous lenses by traveling a greater or less distance through the closer, harder sandstone, in which case according to Griswold's interpretation of the Anticlinal Theory, it either moved by gravity, if the sandstone is unsaturated, or by difference in specific gravity if the sandstone is saturated with salt water. Not considering the fact that water is found in the pay streaks, the first way can be discarded as impossible, because most of the oil is located along the axes of anticlines. If we assume that this oil has been transported and collected in the pay streaks by difference in gravity of the oil and water, we must assume that it has traveled laterally through the hard, close sandstone for considerable distances where the sand has a maximum dip of not more than 1 foot in 50 feet. If this is possible, what is to prevent the oil from collecting at the top of the sand on the crests of the anticlines with the entire lower portion of the sandstone saturated with water? If the close, hard, sandstone is admittedly sufficiently porous to permit the passage of oil particles through its waterlogged pores at a very small dip, and with a pressure of less than half the weight of the moving globules of oil, it seems reasonable to suppose that with the enormous pressure under which the oil and water is found, either water or oil should be forced out of the sandstone in perceptible quantities throughout its entire thickness. Incidentally, by his statement Griswold can be forced to assume that the great pressure of the oil, water, and gas in the porous streaks comes primarily from the pressure of the gas forming from the petroleum after it has reached the pay streaks. In this instance it is hard to see how these gas pressures can be localized, since if the oil is free to move in at a pressure of less than one-half its weight, the gas should much more easily flow out and dissipate its pressure throughout the whole rock mass as rapidly as it is formed. The initial closed pressure of closely associated pools is rarely the same, and the evidence tend to show that it varies greatly in different pays of a given plane, and even of the same well. These facts alone show fairly conclusively that the oil in all, or nearly all, of the pools in the Hundredfoot sand on the Sewickley quadrangle has not been collected by gravity, acting either directly, or indirectly through the agency of still water.

In attempting to apply the generally accepted rules of oil and gas accumulation, as laid down by the Anticlinal Theory, to the known pools in the Gordon, Boulder, Snee, Fourth and Fifth sands of the Sewickley quadrangle, difficulties as great as those mentioned for the

Hundredfoot sand are encountered. In all these sands, with the single exception of the Gordon sand in the Coraopolis pool, little or no water is found with the oil. This is especially true of the pools that are thought to be in the Boulder and Snee sands. So far as the writer could learn, these sands never furnish water with the oil, yet the Grubbs pool, which is either in the Gordon or Boulder sands, is located squarely on top of the Brush Creek anticline. As mentioned before, this pool seems to be confined entirely to a loose, porous patch of sand, surrounded by an area of harder, closer sandstone. In the Craig and Davis pools the Boulder sand produces both oil and gas without water, though the pool is located near the bottom of the Sewickley syncline. No water has been reported in wells tapping this sand at a lower level along this trough. In all cases the pools seem to be limited by the extent of the loose, porous patches of sand, regardless of structure.

In the Grubbs pool, if the sand is not saturated with water, the oil could have traveled down the slope of the sand only from a small area along the crest of the anticline farther to the north. It is not reasonable to suppose that such a movement could develop a pressure sufficient to furnish a number of wells each flowing more than a hundred barrels of oil per day. If the pressure which causes these wells to flow was originally produced by expansion of gas generated in the oil pool after it had formed in the porous patch of sand, it seems sensible to conclude that this pressure would have been sufficient to force the oil back into the harder sandstone through which it is supposed to have formerly traveled at a much less pressure.

Since the Craig, Davis and Grubbs pools are at practically the same location in the sand, it would naturally be assumed that they mark the top of the saturated portion of this sand. If this be true, and the oil has traveled up the slope of the satured sand and gathered at the water line, there is apparently no reason why the gas should not easily diffuse throughout the dry rock above, since there can be no doubt that the sandstone has sufficient open space in it to admit of such diffusion. With this condition, we should also get copious flows of salt water from the Boulder down the slope of the sand. The most favorable place for water is at the bottom of the Mt. Nebo syncline, in the vicinity of Stonedale, but no water is mentioned as coming from the Boulder there, though in some cases the sand is said to have had a good pay.

The conditions as shown in the Grubbs field are more or less evident in all the other producing areas of the quadrangle, as has already been pointed out in the discussion of these pools by townships. Since these facts are so nearly diametrically opposed to what should be expected from the anticlinal theory, the writer has no hesitancy in stating that most of the oil pools on the Sewickley quadrangle, to a great extent at least, owe their existence to geologic processes other than those mentioned above in this theory. At the same time, there is no doubt that structure has been very influential in causing these accumulations.

Shortcomings in the Anticlinal Theory as stated above. The greatest weakness in this and all previous statements of the Anticlinal Theory lies in the fact that no adequate means is provided for the movement of the oil from the shales in which it was formed to the sandstones that now contain it. Whether this oil has its origin in bacterial action on the vegetable or animal matter in the mud at the sea bottom, or was laid down as a petroliferous clay, or else distilled from bituminous matter imbedded in the shales, it doubtless first occurred as isolated microscopic globules more or less completely entombed in the shales. There is no means of ascertaining the ratio of oil thus formed, to the shale mass which enclosed it at any given point, but except in rare instances it was doubtless very small. These tiny globules were probably absorbed by particles of clay with which they first came in contact. In such a condition capillary diffusion was restricted to the almost microscopic areas of clay that could be saturated by each separate oil globule. Probably only exceptionally rich areas furnished sufficient oil to satuate any considerable patches of the shale.

There is a gap in the Anticlinal Theory from this stage of the development of an oil pool to the point where the oil enters the porous sandstone. Vagne reference is made by some authors to capillary action to account for this movement. Under the above conditions, this was probably totally inadequate to do the work. Dr. David T. Day*(a)* has clearly demonstrated that capillary diffusion can not take place in the best medium known (Fuller's earth) in the presence of a very large amount of intersticial water. There has doubtless been no time in the entire geologic history of the oil-bearing shales of Pennsylvania when they have not contained a considerable amount of water, and in the first two cases named, they were doubtless completely saturated at the time the oil was formed. Many geologists have suggested hydrostatic pressure as the agent through which this movement has been accomplished. Since hydrostatic pressure is the pressure of water in a state of equilibrium, this statement must be interpreted to mean that the tiny globules of oil were separated from the clay by which they were doubtlessly absorbed, and passed through the microscopic water-barred interstices of the shale by difference in specific gravity. Orton*(a)* touching upon this point says:

> "Another fact to be noted in this connection is the affinity of clay for oil of all sorts. Illustrations of this affinity are familiar to every one, but an observation of Professor Joseph Leidy's, made a

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(a) Unpublished experiments in diffusion of Petroleum through Fuller's earth.
(a) Geol. Survey of Ohio, vol. VI, pp. 72-73.

number of years since, has special interest and value for us. He observed that on the bed of the Schuylkill river, for some distance below the Philadelphia gas works, a deposit of clay, impregnated with the petroleum-like oils that are produced in the manufacture of coal-gas, was in process of formation. These oily substances, which would otherwise be found on the surface of the river, are absorbed by the particles of fine clay in the water and gradually sink to the bottom with them, there forming a petroliferous clay on the river bed."

Continuing this line of thought, he says:

"The shales that were slowly accumulating on the floor of this tropical gulf, thus charged with vegetable remains, must have behaved as similar shales do around the borders of the present gulf. The vegetable matter was turned into petroleum as it is in Trinidad and the West Indies now. The petroleum would have been absorbed by the particles of clay in contact with which it was originated, or, if liberated in the water, it would there have been laid hold of by the like floating particles of clay, to be carried with them in due time to the sea-floor, and the work would have gone on until the material was exhausted or the requisite conditions were lost.

"The resulting stratum of bituminous shale would have been much more highly charged with petroleum than any portion of these shales is at the present time. Over it at last a bed of sandstone is deposited, which in turn is roofed in by another finegrained shale. *The pores of the sandstone are occupied by seawater, but a slow system of exchanges would be established between the rocks by which, at last, the petroleum would be gathered into its final reservoir."*

The last sentence of this quotation (the italics are the writer's) epitomizes the arguments made by those favoring hydrostatic pressure as the agency of transportation. Considering these quotations together, it can readily be seen that Dr. Orton has very effectively rebutted his own argument. If the affinity of clay for oil is great enough to hold this oil securely while it is being deposited as petroliferous shale on the open sea bottom, will this affinity, plus friction, not as securely hold the oil after this shale is covered by a sandstone? What other force but difference in weight of the oil and water could possibly, under the conditions stated, have anything to do in establishing the slow system of exchanges to which he refers?

The simplest laboratory experiments will verify Leidy's observation; but in the oil-soaked soil around every producing oil well in Pennsylvania we can find without end demonstrations of this truth. In a clay of this density completely saturated with water as these must have been, the static coefficient of friction would be relatively enormous and would doubtless furnish ample resistance to the movement of the oil by difference in specific gravity, which at its maximum exercises a force equal to only about one-half the weight of the oil. Again, if we accept hydrostatic pressure as the medium of this slow exchange, can we consistently consider the shale roof which covers the pay rock in the oil fields of Pennsylvania an *impervious cover,* as required by the Anticlinal Theory?

It must be conceded that the Anticlinal Theory as it is generally stated, exhibits some weakness in providing a competent agent for the movement of the oil from the shaless to the sandstone.

If we assume, as Griswold does, that the oil has been transmitted by some mysterious process from the shales to the sandstones, it might be of value to study in some detail the provisions made by the Anticlinal Theory for subsequent movements of the oil in the sandstones. Griswold says:

> "If small quantities of oil and gas enter a dry porous rock at different points, the oil will flow down as long as gravity is sufficient to overcome the friction and the capillary attraction. The gas will diffuse with the air or water vapor contained in the pores of the rock.
>
> "Oil and gas entering a porous rock that is completely saturated with water will be forced up to the top of the porous stratum by the difference in the specific gravity of the hydrocarbons and the water. Here the oil and gas will remain if the porous stratum be perfectly level, *but if it has a dip sufficient to overcome the friction,* the particles of oil and gas will gradually move up this slope, the gas with its lower specific gravity occupying the higher places."

This is an orthodox statement of the fundamental principles of what is generally accepted as the Anticlinal Theory; and very effectively expresses the crux of the whole problem. Therefore, the first and most important question is,—What dip is necessary to overcome friction?

As a simple illustration: If we lay a stone or any other object on a horizontal board and then slowly tip the board, when a certain angle is reached the stone will begin moving down the slope. This angle depends upon the shape, size and weight of the stone and the degree of smoothness of the board. If the tilting is arrested an instant before this angle is reached the stone will remain motionless indefinitely. So with these small patches of oil scattered along the roof and floor of an oil-bearing sandstone: movement in any direction can take place only when the static coefficient of friction of the oil for a sandstone of this porosity is overcome. In a dry sandstone the tendency of the oil would be to move down in a vertical direction by a force equal to the weight of the oil. If the sandstone be saturated with water the tendency is to move vertically upward by a force equal to the difference of weight of the water and oil, which is less than one-half the weight of the oil. So in a sand of a given porosity the minimum dip at which oil can travel, if the bed is saturated with water, is over twice that needed if the sand is unsaturated.

In all of the catchment areas for pools examined in Pennsylvania, the dip of the oil sand seldom, if ever, exceeds 200 feet to the mile and will not average 100 feet. This gives a maximum dip of about 4½ degrees, or a fall of one foot in every twenty-six, the average being less than one foot to sixty feet. Without going into the purely mathematical aspect of the problem, it can be readily seen that the force actually exerted toward horizontal motion, by a saturated patch or a single globule of oil, under such a dip, would be but a very small fraction of the maximum force mentioned above for vertical movement in the sandstone.

When we consider the resistance offered to this movement by irregularities in the roof and floor of the sandstone, and the molecular repulsion offered by salt water to oil which would prevent diffusion, in the saturated bed, to say nothing of the relatively enormous static friction offered by the waterlogged interstices of even the loosest, coarsest sandstone; and in a dry rock, the effect of capillary attraction in all directions, the intersticial molecular cohesion of the oil around sand grains and its adhesion to the capillary walls; the absurdity of attributing the accumulation of such enormous pools of oil under high pressure to hydrostatic pressure (the pressure of still water) can readily be seen.

A glance at Plate I will show that most of the enormous gas fields of Pennsylvania lie to the east of the great oil belt. In this gas region, the rocks are, as a rule, much more steeply folded than they are in the oil fields. So far as comparisons have been made, there is no perceptible difference in the porosity of the producing sands in the two areas. The fact that gas occurs in these steeper anticlines shows conclusively that the porous sand has a sufficiently impervious cover to hold oil if it were present. It is reasonable to suppose that if the gas has been derived from matter deposited with shales of the region in which it is now found, the same source would have most likely furnished large quantities of the very similar, but less volatile, hydrocarbon compounds of which oil is composed. According to Griswold's interpretation of the anticlinal theory as given above, this area should therefore be especially favorable to oil accumulation, since the steeper dip would be more effective in moving the oil. It is in fact conspicuously barren. Also by this theory we should find gas pools in areas too flat to cause accumulations of oil. Applied in a regional way, it can be easily shown that other important factors, whatever they may eventually prove to be, are involved in the accumulation of oil and gas pools.

Possible causes of accumulation of oil pools in Sewickley quadrangle.

While it is possible that pools of oil have been formed within this area through the generally accepted processes of gravity and hydrostatic pressure, the geologic evidence tends strongly to show that most of the pools were not so formed.

Just what other factors were involved is not clear, and the writer frankly admits that sufficient data is not available to justify a serious attempt to formulate a theory that will account for the occurrence of all of these pools. The problem is to a great extent a regional one, and involves the collection and careful study of an immense amount of detailed facts regarding the stratigraphy of the oil sands, and a special study of the salt water conditions in each of them, over wide areas, both as to extent and geologic history. In addition to this it is believed that a more intimate knowledge of the initial closed pressure of gas wells throughout southwestern Pennsylvania would go far toward solving the problem, also the history of incursions of salt water, and of folding.

With the data now in hand on this and adjacent quadrangles, to the south and southwest, the writer suggests that geologists studying the oil and gas fields of Pennsylvania, West Virginia, and Ohio, may find it worth while to give close attention to the effects that might have been produced on the location of the oil and gas pools by moving water.

It may be shown that the hydraulic principle of oil and gas transportation lends itself readily to the explanation of many of the most perplexing phases of the problem, and it is possible that when more is known in a regional way, of the age, history and movements of the salt water enclosed in the oil-bearing formations, the solution of the enigmatic question of oil and gas accumulation may be more confidently answered. When this knowledge is finally won, the writer suspects that movement of oil from the mud and shales to sandstones will be considered due principally to currents of moving water forced upward from the forming shales by differential compression of the shales and the overlying sands, as succeeding strata were laid down on the sea bottom; and that subsequent movements of the oil in the sandstones were principally due to structural changes that set up slow circulations of the original water of deposition, which may have from time to time been augmented by meteoric waters. The present position of the pools may be found due to a complication of structural factors both local and regional that effected the direction and velocity of water currents, and to favorable lithological conditions by which the emulsion of oil, gas, and water resulting from such an association, has had an opportunity to resolve itself into its component parts, through difference in specific gravity. Oil and gas pressure may be found to result from the expansion of gas formed from oil in the present pools, which is prevented from diffusing throughout the sandstone by the resistance offered by water, either hydraulic or interstical, and to the force executed on gas bodies by enveloping water under hydraulic pressure.

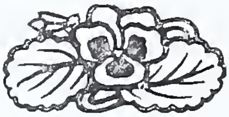

TABLE SHOWING THICKNESS OF OIL SANDS, AND THE INTERVALS BETWEEN THEM, AS GIVEN IN RECORDS OF WELLS ON THE SEWICKLEY QUADRANGLE.*

	Average
Top of 100-ft. to top of Butler gas sand.	[illegible]
Top of 100-ft. to bottom of Butler gas sand.	[illegible]
Thickness of Butler gas sand.	[illegible]
Top of 100-ft. to top of Big Injun.	[illegible]
Top of 100-ft. to bottom Big Injun.	[illegible]
Thickness of Big Injun.	[illegible]
Thickness of 100-ft.	[illegible]
Top of 100-ft. to top of 30-ft.	[illegible]
Bottom of 100-ft. to top of 30-ft.	[illegible]
Thickness of 30-ft.	[illegible]
Top of 100-ft. to top of Stray.	[illegible]
Bottom of 30-ft. to top of Stray.	[illegible]
Thickness of Stray.	[illegible]
Top of 100-ft. to top of Boulder.	[illegible]
Bottom of Stray to top of Boulder.	[illegible]
Thickness of Boulder.	[illegible]
Top of 100-ft. to top of Third.	[illegible]
Bottom of Boulder to top of Third.	[illegible]
Thickness of Third.	[illegible]
Top of 100-ft. to top of Fourth.	[illegible]
Bottom of Third to top of Fourth.	[illegible]
Thickness of Fourth.	[illegible]
Top of 100-ft. to top of Fifth.	[illegible]
Bottom of Fourth to top of Fifth.	[illegible]
Thickness of Fifth.	[illegible]

*Measurements in feet.

APPENDIX.

Two grades of spirit leveling were done for vertical control in the topographic and geologic work on the Sewickley quadrangle. The primary, or more precise leveling, was first run for the purpose of establishing permanent bench marks, at about every five miles distant over the quadrangle. The location of these points are shown on the topographic map by a cross marked B. M. Intermediate points on these lines are distinguished on the geologic maps by a P. before the corresponding bench mark number, as shown in the list below. From these primary bench marks secondary lines were run in much smaller circuits over nearly all the roads. The descriptions of all these bench marks are accompanied by numbers corresponding to those on plates V and VI, showing their field location. At the time each of these bench marks was made, its elevation above sea level as then determined was marked up with white paint in some conspicuous place where it would easily catch the eye of the geologist in passing. This original elevation is given in the first column of the list below. When the circuit of a level line was closed, the closure error, if any, was adjusted through the whole line, and this adjustment of the painted elevations frequently shows them to be more or less in error. These adjusted elevations, as given in the last column, should be given preference in any level work, using these levels as a base.

	Primary Bench Marks.	Original Elevation	Adjusted Elevation
P. 1.	Bronze tablet on northwest bridge seat of small culvert bridge; 1,400 ft. north of station at Downieville, ..	1036.	1035.34
P. 2.	Bridge over small stream,	1101.	1100.67
P. 3.	Nail in root of oak tree,	1272.	1271.7
P. 4.	Nail in root of ash tree,	1117.	1116.20
P. 5.	Stone arch at cross roads,	1079.	1078.6
P. 6.	Bronze tablet marked "1066 Pitts" in southwest coping stone of bridge over Brush Creek,	1066.	1066.1
P. 7.	On stone foundation on west side of road at forks,..	1073.	1073.95
P. 8.	Bridge over small stream,	1048.	1047.8
P. 9.	Bridge over small stream,	1054.	1053.6
P. 10.	On property cornerstone at road crossing.	1100.	1099.28
P. 11.	Bronze tablet in foundation of store at Lovi,	1138.	
P. 12.	Nail in root of tree at cross roads.	919.	918.84
P. 13.	Aluminum tablet in north end of southeast wing wall of iron highway bridge over Crows Run near Parks Store,	802.	801.79
P. 14	On stone at entrance of Keowins Hotel,	1148.	1147.07
P. 15.	On east end of south wall of stone arch bridge over Gintis Run,	1057.	1056.51
P. 16.	At road forks,		1183.5
P. 17.	Bronze tablet in northeast wing of wall of iron bridge over Lowries Run,		880.94
P. 18.	Bridge over Lowries Run at oil station,		844.7
P. 19.	Bridge floor,	829.	828.5

		Original Elevation	Adjusted Elevation
P. 20.	Bronze tablet on bridge No. 15, second step from top of northwest wing wall, ...		710.119
P. 21.	On southeast abutment of P. & L. E. R. R. bridge over Montour Run, on north or river side of abutment and on northwest fact of abutment, 8 ft. north of north rail of railroad, and 7 ft. below top stone of abutment; bridge iron girder rests on this stone, ...		709.059
P. 22.	On top of west corner of abutment at north end of Montour Bridge (Neville Island end), over back channel of Ohio river at lower end of Neville Island; 4.9 ft. below top of stone of abutment and is on stone upon which the northwest iron truss rests and is 3 ft. northwest of said iron truss, marked thus: U. M.		717.640
P. 23.	On stone water table on southeast end of P. & L. E. R. R. station at Coraopolis, Pa., 4 courses of stone below top of stone foundation and 7 ft. south of southeast corner of building, ...		721.114

SECONDARY LEVEL BENCH MARKS.

1.	Painted square on top plank of fence northeast of road fork, ...	1177.0	1175.8
2.	Painted square on stone culvert at road fork, ...	1221.4	1220.0
3.	Painted square on top of fence post at northeast corner of road crossing, ...	1142.7	1142.9
4.	Painted square on stone at southwest corner of road forks, ...	1142.7	1142.7
5.	Painted square on bottom plank of fence at northeast corner of road fork, ...	1116.7	1116.7
6.	Painted square on root of oak tree at road forks, ...	1142.0	1142.0
7.	Painted square on east end of sewer pipe under road at stream crossing, ...	1092.0	1092.3
8.	Painted square on stone post in front of school house, ..	1165.0	1165.0
9.	Painted square on log inside of fence, ...	927.6	927.8
10.	Painted square on sandstone ledge west of road fork, ..	746.1	744.7
11.	Painted square on culvert at bend in road, ...	1116.5	1115.1
12.	Painted square on top of southwest coping stone of bridge, ...	824.2	824.7
13.	On nail in hitching post at road forks, ...	1190.3	1188.9
14.	Painted spot on culvert at lane forks, ...	1200.9	1199.6
15.	Ground at center of road on top of hill at lane to east,	1149.6	1149.7
16.	Painted square on stone at road crossing, ...	803.1	803.8
17.	Painted square on small stone at road forks, ...	824.4	825.2
18.	Painted square on small stone at north side of road, ..	850.7	851.5
19.	Painted square on small stone to west of road forks, ..	861.1	862.6
20.	Painted square on stone in road forks, ...	891.0	891.0
21.	Painted square on small wooden culvert in road fork, ..	1070.6	1072.2
22.	Painted square on end of culvert at road crossing, ...	1086.2	1086.9
23.	Painted square on coping stone of culvert where road turns west, ...	751.0	751.8
24.	Painted square on abutment of bridge at road forks, ..	766.6	767.4
25.	Painted square on top of stone gate-post at road forks,	744.6	745.0
26.	Painted square on root of oak tree to west of road at sharp bend, ...	911.7	912.9
27.	Painted square on stone in center of road at sharp bend on top of hill, ...	1147.1	1148.8
28.	Painted square on sill in front of blacksmith shop at road forks, ...	771.0	771.0
29.	Painted spot on sand rock at road forks, ...	1141.3	1141.4
30.	Painted spot on rim of water plug at road forks, ...	1164.6	1164.7
31.	Painted spot on top of water plug at road forks, ...	1142.0	1142.5
32.	Painted spot on wood sill of steel girder bridge at road forks, ...	842.3	......
33.	Painted spot on top of stone culvert over ditch at road forks, ...	1176.0	......
34.	Painted spot on root of apple tree at road fork, ...	1192.7	......
35.	Painted spot on root of tree at road forks, ...	1207.0	1207.1
36.	Painted spot on tile culvert at cross roads, ...	1105.3	......
37.	Painted spot on root of maple tree at road forks, ...	830.7	......
38.	Painted spot on bridge at road fork, ...	751.9	......
39.	Painted spot on sand rock by gate at road fork, ...	740.3	......
40.	Painted spot on top of stump at road fork, ...	1140.6	1140.7
41.	Painted spot on bridge at road forks, ...	806.8	806.8

		Original Elevation	Adjusted Elevation
42.	Painted spot on gas pipe at road forks,	795.3	795.4
43.	Painted spot on sidewalk at intersection of 3rd and Merchant Sts.,	763.6	763.7
44.	Painted spot on corner of sidewalk at intersection of 14th and Merchant Sts.,	756.0	756.1
45.	Painted spot on stone in road forks,	1141.4	1138.4
46.	Top of east rail of railroad,	746.6	743.6
47.	Painted square on top of fence-post at northeast of sharp bend in road,	1196.7	1193.7
48.	Painted square on top of cement culvert at road forks,	718.1	715.1
49.	Painted square on floor of wood bridge at sharp bend in road,	916.8	......
50.	Painted on culvert at road fork,	858.7	......
51.	Painted spot on sand rock beneath fence corner at road forks,	1020.1	......
52.	Painted spot on root of dogwood tree at road forks,	1041.3	1041.4
53.	Painted spot on bridge at road forks,	783.7	......
54.	Painted spot on sand rock at road forks,	794.5	794.6
55.	Painted spot on sand rock at road forks,	831.3	831.3
56.	On gas pipe,	804.4	......
57.	Painted spot on bridge at road forks,	834.6	......
58.	Painted square on sand rock on east side of road fork,	901.8	......
59.	Painted square on end of wood culvert at road fork,	894.4	......
60.	Painted square on sand rock by sign post at road fork,	1182.8	......
61.	Painted square on bridge at road fork,	985.0	......
62.	On ground by sign post at road forks,	1182.0	......
63.	On ground by sign post at road forks,	1105.4	....
64.	On ground on north end of stone culvert at road forks,	937.5	......
65.	On bridge at cross roads,	973.1	......
66.	On tree root,	1175.0	......
67.	On stump to south of road forks,	1290.6	......
68.	On sand rock at road forks,	1301.0	......
69.	On iron pipe culvert at road forks,	1225.4	......
70.	On bridge at road forks,	1131.5	......
71.	On sand rock on west side of road forks,	1261.1	......
72.	On square on stone in road forks,	1056.5	......
73.	On square on wooden culvert to southwest of lane to west,	995.4	......
74.	On square on small gas pipe at road forks,	939.0	......
75.	Ground at foot of mail box,	880.	......
76.	Painted square on gas pipe to west of road forks,	1216.4	......
77.	Painted square on stone in road forks,	1210.6	......
78.	Painted square on stone to west of road forks,	1210.4	......
79.	Painted square on large root in road at fork,	1253.3	......
80.	Painted square on top of 4th fence-post from corner on north side of road going east,	1164.5	......
81.	Painted square on limestone boulder to west of road forks,	1032.4	......
82.	Painted square on small stone to west of road forks,	946.8	......
83.	Painted square on south end of stone culvert at road forks,	877.2	......
84.	Painted square on sill of steel girder bridge at road forks,	906.3	......
85.	Painted square on southeast corner of floor of bridge at road forks,	982.6	......
86.	Painted square on stone culvert at road forks,	1059.	......
87.	Painted square on sand rock at northeast corner of road forks,	1118.	......
88.	Ground at foot of sign-post,	1148.4	1146.1
89.	Painted square on stone culvert opposite road fork to west,	1163.3	......
90.	Painted square on north end of stone bridge,	912.8	912.9
91.	Painted square on stone in front of new school house at road forks,	1175.0	1185.
92.	Painted square on south end of small culvert at road forks,	1033.7	......
93.	Painted square on small limestone at foot of sign-post,	1104.2	......
94.	Painted square on stone in forks of pipe,	993.8	......
95.	Painted square on wood bridge,	1135.7	1135.5
96.	Nail in root of tree to northeast of road forks,	1190.2	......
97.	On root of locust tree at forks of lane,	1178.9	......
98.	Painted square on coping stone at road forks,	722.0	......
99.	Painted square on stone to north of road,	1006.3	......
100.	Painted square on culvert on south side of road forks,	1294.9	......

		Original Elevation	Adjusted Elevation
101.	Painted square on sand rock in middle of road forks,	1184.5	......
102.	Painted square on sand rock in middle of road forks,	1029.7	......
103.	Painted square on sand rock at road forks,	1273.2	......
104.	Painted square on sand rock at road forks,	1248.6	......
105.	Painted square on southwest end of west wing wall of bridge at road forks,	974.8	......
106.	Painted square on stone at mouth of lane opposite road forks,	1182.2	......
107.	Painted square on cement culvert in northwest corner of road forks,	1113.3	......
108.	Painted square on stone culvert to west of road at road forks,	1077.4	......
109.	Painted square on gas pipe opposite post,	1104.8	......
110.	Painted square on north end of small culvert at road forks,	1118.3	......
111.	Painted square on cement culvert about 20 ft. north of road forks,	1008.4	......
112.	Painted square on west end of retaining wall on south side of road opposite forks,	900.7	......
113.	Painted square on stone near south corner of triangle at forks of road,	1129.8	......
114.	Painted square on stone at forks of lane to north,	1115.2	......
115.	Bottom of coal in coal bank,	1050.5	......
116.	Painted spot on southwest corner of south coping of bridge,	911.8	......
117.	Painted spot on wood culvert to east of road forks,	1110.3	......
118.	North rail of railroad on hill at road forks,	1224.9	......
119.	Floor of bridge about 50 ft. east of road forks,	973.9	......
120.	Top of coal in coal bank,	1120.4	......
122.	Top of casing of well, N. L. Lutz, No. 1,	947.9	......
123.	Top of coal,	970.8	......
125.	Top of coal,	1094.0	......
126.	Top of casing of well—L. D. Brenner, No. 3,	990.	......
127.	Top of casing of well—C. H. Rape,	1041.8	......
128.	Top of casing of well—Clever No. 2,	1026.0	......
130.	Top of casing of well—Mrs. Margaret Lotz, No. 2,	1115.5	......
131.	Top of casing of well—Wm. Piersol, No. 1,	987.1	......
132.	Top of casing of well—David Black, No. 1,	1088.8	......
133.	Top of casing of well—N. F. Hurst,	979.0	......
134.	Top of casing of well—Wm. Phillips,	1165.5	......
135.	Top of casing of well—Christ Goehring,	1125.5	......
137.	Top of casing of well—John Baker, No. 1,	1141.1	......
138.	Top of casing of well—C. T. Goehring, No. 1,	1220.7	......
139.	Top of casing of well—Anna Wolf, No. 4,	1145.	......
140.	Top of casing of well—Dane Bradford, No. 1,	1110.0	......
141.	Top of casing of well—Rich. Henry, No. 1,	1121.4	......
143.	Top of casing of well—Eerman, No. 1,	802.9	......
146.	Top of casing of well—Mrs. Hoening, No. 1,	875.0	......
149.	Top of casing of well—Wm. Erwick, No. 1,	1064.3	......
151.	Top of casing of well—Jas A. Montgomery, No. 1,	1183.5	......
152.	Top of coal,	941.8	......
153.	Top of coal,	1216.0	......
155.	Top of casing of well—Newton Garvin, No. 23,	1193.7	......
157.	Top of coal,	1059.0	......
158.	Top of casing of well—Wm. Davidson, No. 5,	1018.2	......
160.	Top of casing of well—Edw. Little, No. 1,	1155.5	......
161.	Top of casing of well—Kauffman Heirs, No. 3,	1053.6	......
162.	Top of casing of well—J. W. Cashdollar, No. 1,	1098.7	......
163.	Top of casing of well—Jacob Dumbough, No. 2,	1059.5	......
164.	Top of coal,	1118.9	......
165.	Top of coal,	1160.6	......
166.	Top of casing of well—Mrs. Lizzie McKinney, No. 2,	1101.	......
167.	Top of casing of well—David Hendrickson, No. 1,	1189.1	......
170.	Top of casing of well—Duetil, No. 1,	1045.0	......
171.	Top of casing of well—C. W. Clark, No. 5,	1281.1	......
172.	Top of casing of well—J. C. McDonald, No. 2,	1157.4	......
174.	Top of casing of well—Mrs. Nettie Campbell, No. 2,	1107.0	......
175.	Top of casing of well—John Balford, No. 8,	1113.9	......
176.	Top of casing of well—Anderson Kennedy, No. 4,	1026.9	......
178.	Top of casing of well—Sandle Heirs, No. 4,	1181.6	......
179.	Center of road at forks,	1267.	......
180.	Center of road at forks—Robinson Heirs, No. 1,	1068.9	......
181.	Painted square on bridge,	854.0	850.9
182.	Top of casing of well—Jno. Logan, No. 1,	1098.0	......

		Original Elevation	Adjusted Elevation
183.	Top of casing of well—Fred Brant, No. 1,	1278.5	......
184.	Top of casing of well—Geo. Raulshouse, No. 1,	1045.0	......
185.	Top of casing of well—Emmet,	1259.1	......
186.	Top of casing of well—Sam Campbell, No. 1,	1200.0	......
187.	Top of casing of well—Sam McCush, No. 1,	1150.0	......
188.	Top of casing of well—Bradford, No. 2,	1104.1	......
189.	Top of casing of well—G. I. Sickles, No. 1,	1048.7	......

LIST OF PARTIAL RECORDS OF WELLS ON THE SEWICKLEY QUADRANGLE.

MOON TOWNSHIP, ALLEGHENY COUNTY.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
1	P. H. Stevenson,	1	Fitzgibbons & Jordon,	1,232	Gordon,	2,135	7		Water in Gordon. Oil.
2	Samuel Stevenson,	1	Fitzgibbons & Jordon,	1,222	Gordon,	2,136	6		Water in Gordon. Oil.
3	John Stevenson,	1	Fitzgibbons & Jordon,		Gordon,	2,120	19		Water in Gordon. Oil.
4	G. G. Stevenson,	1	South Penn. Oil Co.,	1,174	Gordon,	2,679	13		Oil.
5	Lewis Hood Heirs,	1	Kanawha Oil Co.,	1,083					Fresh water at 40 ft.
6	W. A. Rouser,	1	South Penn. Oil Co.,	(?)1,120	Gordon,	2,078	9½		24 bbls. per day. Oil.
					Fourth,	2,140	4		Small gasser. Gas.
7	Martha Getty,	3	South Penn. Oil Co.,	1,126	Gordon,	2,045	9		Oil.
8	Neeley Heirs,	7	South Penn. Oil Co.,	1,177	Gordon,	2,088	10		Oil.
9	Martha Getty,	4	South Penn. Oil Co.,	1,208	Gordon,	2,124	11		Abandoned 1902. Oil.
10	Neeley Heirs,	(?)2		1,023					
11	William Cooper,	1	South Penn. Oil Co.,	950		1,879	6		Oil, also salt water.
12	Kerr,	(?)		884	Gordon,				Large well. Oil.
13				832	Dry hole,				
14	E. Cassidy,	5	South Penn. Oil Co.,	792	Gordon,	1,713	9		225 bbls. per day. Oil.
15	E. Cassidy,	1	South Penn. Oil Co.,	780	Gordon,	1,698	12		220 bbls. per day. Oil.
16	E. Cassidy,	3	South Penn Oil Co.,	763	Gordon,	1,675	8		Oil.
					Fourth,		12		Strong flow. Gas.
17	Vandevort,	1	Montour Gas Co.,	894	Fourth,	1,843			Gas. Gordon 45 ft. thick. No oil. Water in 100-ft.
18	Thos. Sterling,	1	Lawrence Gas Co.,	1,185	Fourth,				Gas. Poor record.
19	S. C. Dally,	1	Lawrence Gas Co.,	1,180	Hundredfoot,	1,800			Show of oil with water.
					Gordon,	2,070			
					Fourth,	2,132			Gas. Large gas well.
20	Stackhouse,	1		972	Fourth,				Small gasser.
21	J. J. Miller,	1	South Penn. Oil Co.,	1,083	Hundredfoot,	1,685	45		Salt water.
					Gordon,	1,950	15		
					Fourth,	2,019	11		Gas. Good gas well.

22	L. F. Arnsburg,	1	South Penn. Oil Co.,	797	Hundredfoot, Gordon, Fourth,	1,428 1,678 1,734	29 10 12		Show of oil; salt water.
23	L. F. Arnsburg,	2	South Penn. Oil Co.,		Gordon, (?) Fourth,	1,740 1,840			Gas well.
24	Parks,	1		1,141					
25	D. O. Vandevort,	1		862	Hundredfoot, Gordon, Fourth,	1,464 1,710 1,778	38 17 19		Salt water. 7-ft. coal at 392.
26				1,095					
27	Wm. Purdy,			851					
28	Scott,	1	Bridgewater Gas Co.,	940					
29	Alexander Stevenson,	1		1,141					Show of gas in Fourth.
30									Good gas well.
31	Wm. Sheets,	1	E. E. Laughner,	957	Hundredfoot,	1,560	30		
32	E. Worth,	1		796				(?)1,726	Gas in Fourth.

CRESCENT TOWNSHIP, ALLEGHENY COUNTY.

35	Hoffman,	1	E. E. Laughner,	746	Hundredfoot,	1,342	30	1,387	Oil and salt water.
36	Gardner,	2	E. E. Laughner,	730	Hundredfoot, Gordon, Fourth,	1,325 1,588 1,628	34 20	1,732	Salt water. Gas in Fourth.
37	Cinderella Gardner,	1	E. E. Laughner,	723	Hundredfoot, Fourth,	1,318 1,616	 12		Oil and salt water.
38	Point Well,		E. E. Laughner,	717	Hundredfoot, Fourth,	1,330	31		Oil and water. Good gas well.
39	B. M. Porter,	1	E. E. Laughner,	820	Hundredfoot,	1,401	39	1,446	Oil and salt water.
40	Luna Gilchrist,	1	E. E. Laughner,	823	Hundredfoot, Fourth,	1,415 1,722	35	1,796	Oil and salt water. Gas.
41	Kaines,	2	E. E. Laughner,	780	Hundredfoot,	1,278	29		Oil and salt water.
43	A. A. Porter,	1	E. E. Laughner,	713	Hundredfoot,	1,322			Gas and oil.

LEET TOWNSHIP, ALLEGHENY COUNTY.

45	Ezra Young,	1	Ezra Young,	705	Hundredfoot, Fourth, Fifth,	1,270 1,577 1,621	84 12 15		Coal, 2 ft. at 98 ft. Coal, 3 ft. at 243 ft. Gas at 1,577. Gas.
46	R. K. Wilson,	11	R. K. Wilson,	711	Hundredfoot,	1,291			Oil from 1,296 to 1,306.
47	R. K. Wilson,	12	R. K. Wilson,	719	Hundredfoot,	1,286	34		Oil 1,289 to 1,293 and 1,302 to 1,307.

LEET TOWNSHIP, ALLEGHENY COUNTY.—Continued.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
48	R. K. Wilson,	5	R. K. Wilson,	714	Hundredfoot,	1,293			Oil 1,297 to 1,311.
49	Phillips,	1	Gailey Bros.,	762	Hundredfoot,	1,350	36		Oil in salt water.
50	Phillips,	2	Gailey Bros.,	815	Hundredfoot,	1,407	50		Oil in salt water.
51	Faylor,	2	Bridgewater Gas Co.,	1,130	Hundredfoot, Gordon, Fourth,	1,695 1,946 2,010	43 1 7		Dry. Good gas well.
52	Henry Rosenbauer,	1	Ohio Valley Gas Co.,	1,032					No record. Gas in 4th sand.
53	McKane, (?)	1							No record.

SEWICKLEY TOWNSHIP, ALLEGHENY COUNTY.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Name.	Depth.	Thickness.	Total depth of well.	Remarks.
58	Sevins,	9	Little Sewickley Oil Co.,	807	Hundredfoot,	1,405	28		Good sand 20 ft. thick. Oil in salt water.
59	Sevins,	10	Little Sewickley Oil Co.,	818	Hundredfoot,	1,408	30		Oil and salt water.
60	Sevins,	11	Little Sewickley Oil Co.,	819	Hundredfoot,	1,411	30		Oil and water. Best well in the pool.
61	Sevins,	6	Little Sewickley Oil Co.,	855	Hundredfoot,	1,444	24		Oil and salt water.
62	Sevins,	5	Little Sewickley Oil Co.,		Hundredfoot,	1,585	25	1,876	25 ft. of good sand, but little oil and water.
63	Dairy farm,	(?)	Cochran Flemming,	907					Some gas.
64	George Sohn,	1		1,082	Boulder, (?)	*			Flowing oil well. No salt water.
65	George Sohn,	2			Boulder, (?)	*			Flowing oil well. No salt water.
66	J. D. Prophater,	1							

*No record.

SEWICKLEY HEIGHTS, ALLEGHENY COUNTY.

54	E. B. Taylor,	1	Ohio Valley Gas Co.,	721		*			Gas.
55	McKelvey,	1		721		*			Gas.
56	W. P. Snyder,		W. P. Snyder,	1,107		*			Gas.
67	Frank McKane,			1,165		*			Gas.
68	W. G. Murry,	1	Manufacturers,	1,087		*			Gas.
69	Flemming or Dairy Farm.	(?)2		892		*			Gas.
70	Wm. Knoder Heirs,	1	Philadelphia Co.,	1,131	Hundredfoot,	1,645	105		
					Third,	1,915	20		
					Fourth,	1,972	10	2,051	
71	J. Dusold,	1	Wm. McGee,	1,024				1,950	Some gas.
72	John Wilson,	1	Wm. McGee,	1,159	Salt (?)	1,511	85		Oil in Boulder and Hundredfoot.
					Hundredfoot,	1,636	90		
					Boulder,	1,900	20		
73	S. H. Grubbs,		Philadelphia, Co.,	1,213	Hundredfoot,	1,725			Oil.
					Boulder, (?)	2,005			
74	S. H. Grubbs,		Philadelphia Co.,	1,133	Salt (Butler),	1,510	100		Salt water.
					Hundredfoot,	1,630	80		
					Boulder,	1,909	34	1,945	Oil.
75	S. H. Grubbs,		Philadelphia Co.,	1,142	Salt (Butler),	1,530	115		Salt water.
					Hundredfoot,	1,670	80		
					Boulder, (?)	1,925	29		Oil at 1,944.
91	W. P. Snyder,			1,057	Hundredfoot,	1,617	57		Show of oil at 1,640. Water 1,646-69.
					Fourth, (?)	1,910	15		Some gas.
					Fifth, (?)	1,950	6		
92	S. B. McBride,	1	Philadelphia Gas Co.,			*			
97	Charles Wolfe, (?)	1	Manufacturers L. & H. Co.,	1,185		*			Gas.
98	Lutz,		Manufacturers L. & H. Co.,	998		*			Oil.
99	Henry Wachner,		Henry Wachner,	1,056	Hundredfoot,	1,560	90		

OHIO TOWNSHIP, ALLEGHENY COUNTY.

76	Wm. Morrison,	1	South Penn. Oil Co.,	1,151	Third,	1,957	21		Oil at 1,962.
77	John McCrea,	1	South Penn. Oil Co.,	1,214	Third,	2,030	20		Oil.
78	Mt. Nebo Church,	1	South Penn. Oil Co.,	1,233	Salt (Butler) (?),	1,640	65		Salt water 1,660.
					Third,	2,068			
					Fourth, (?)				Gas at 2,164.
79	Dr. James Thompson,	3	Consolidated Oil Co.,	1,192	Third,	2,041		2,070	Oil.
80	Edward O'Neil,	1	Consolidated Oil Co.,	1,226	Third,	2,054		2,080	

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*No record.

OHIO TOWNSHIP, ALLEGHENY COUNTY.—Continued

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
81	J. Hohman,	1		954	Salt, (?)	1,422	60		Salt water.
					Hundredfoot,	1,497	140		Salt water 1,555 and 1,585.
					Thirtyfoot, (?)	1,668	14		
					Snee, (?)	1,689	5		
					Boulder, (?)	1,702	33		
					Third,	1,810	25		
					Fourth,	1,879	10		Some gas.
82	Joseph Cookson,	1	South Penn. Oil Co.,	(?)1,135	Salt, (?)	1,561			
					Hundredfoot,	1,673	136		Salt water.
					Thirtyfoot,	1,810	25		
					Boulder, (?	1,965			
					Third,	1,996	12		Oil at 2,011.
					Fourth, (?),	2,069	13		Some gas at 2,069.
83	Fred Otman or David George.	1		1,155		*			Gas.
84	O'Neil gas well,	1	Manufacturers L. & H. Co.,	1,205		*			Gas.
85				1,034		*			Gas.
86	John A. Meigan, (?)	1		1,183		*			Gas.
87	E. M. Crawford, (?)	1	Manufacturers L. & H. Co.,	984		*			Coal at 475.
					Hundredfoot,	1,541	89		Gas at 1,551. Gas and oil at 1,609.
					Thirtyfoot,	1,705	8		Hard and close.
					Snee,	1,732	23		Hard and close.
					Boulder,	1,800	14		Hard and close.
					Third,	1,858	30		Hard and close.
					Fourth,	1,927	26	2,016	Gas 1,936-1,938.
88	C. H. Cook,	1	Manufacturers L. & H. Co.,	870		*			Gas.

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*No record.

89	S. Weiss,		Philadelphia Co.,	834	Hundredfoot,	1,365			
					Thirtyfoot,	1,577			
					Boulder,	1,616			
					Third,	1,646			Gas at 1,650.
					Fourth,	1,700			
					Fifth,	1,765			Gas at 1,775.

ALEPPO TOWNSHIP, ALLEGHENY COUNTY.

93	Mrs. MeIntosh,		Gailey Bros.,	809		*			
94	Hummel,	6	South Penn. Oil Co.,	980	Hundredfoot,				Salt water.
					Third,	1,838			Oil 1,840.
95	Hofmeiser,	1	Manufacturers L. & H. Co.,	892		*			Gas well.
96	Geo. Thein,	1	Geo. Thein,	956		*			Gas well.
100	J. C. Fisher,	1	Fisher Oil Co.,	899	Hundredfoot,	1,460			
					Third,	1,778			Gas.
					Fourth,	1,833		1,860	Oil at 1,891.
101	Wendel,	1	Jennings Bros.,	861	Fourth,	1,813	11		Oil.
102	J. W. Moore,	1	John Waehter,	829	Fourth,	1,777	8		Oil.
103	J. W. Moore,	2	John Wachter,	822	Fourth,	1,771	8		Oil.
104	August Ferry, (?)	1	Jennings Bros.,	912	Fourth,	1,869	10	1,895	Oil.
105	Rink, (?)	1	Manufacturers L. & H. Co.,	892	Third,	1,769	25		
					Fourth,	1,835	15		Oil.
106	Peter Rouwolf,	1	South Penn. Oil Co.,	791	Fourth,	1,735	8		Oil.

ROBINSON TOWNSHIP, ALLEGHENY COUNTY.

108	Mrs. Elizabeth Free,	1	South Penn. Oil Co.,	714		*			
109	MeKeown, (?)	2	South Penn. Oil Co.,	716		*			
110	A. J. Verner,	1	Manufacturers L. & H. Co.,	912	Hundredfoot,	1,534	60		
					Third,	1,804	8		Oil.
111	Gibson,	1	Laughner & Wally,	878	Hundredfoot,	1,528	112		Oil at 1,575 to 1,585.
					Thirtyfoot,	1,700	34		
					Third,	1,783	20		Gas at 1,788.
					Fourth,	1,841	24		
					Fifth,	1,925	30	1,975	

*No record.

NEVILLE ISLAND ALLEGHENY COUNTY.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands. Name.	Depth.	Thickness.	Total depth of well.	Remarks.
112	W. A. Shanks,	1	South Penn. Oil Co.,	718	Gordon,	1,645	27		Oil.
113	W. A. Shanks,	2	South Penn. Oil Co.,	715	Gordon,	1,636	11		1st pay 1,636; 2nd pay 1.643; oil.
114	J. W. Phillips,	(?)1		720	Hundredfoot,	1,317		1,446	Gas. (?)
115	J. W. Phillips,	2		719	Hundredfoot,	1,325	125		
					Thirtyfoot,	1,580			
					Fifth,	1,690			
116	Hamilton,	5	Laughner Oil Co.,	730	Hundredfoot,	1,298			Oil, water and gas at 1,435.
					Thirtyfoot,	1,495			
					Third,	1,555			
					Fourth,	1,620			
					Fifth,	1,685		1,720	
117	E. W. Hamilton,	(?)	Hamilton,	723		*			

KILBACH TOWNSHIP, ALLEGHENY COUNTY.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Name.	Depth.	Thickness.	Total depth of well.	Remarks.
122	Dixmont,	15		754	Hundredfoot,	1,320	90		Salt water. (?)
					Thirtyfoot,	1,462	15		
					Snee,	1,510	4		
					Boulder, (?)	1,528	27		Gas at 1,545 to 1,555.
					Third,				None (6 feet coal at 110).
					Fourth,	1,630	20		
					Fifth.	1,690	30	1,743	
123	Dixmont,	16		865					Coal (6 ft. at 355).
					Hundredfoot,	1,398	100		Salt water. (?)

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*No record.

124	Dixmont,	14		1,032	Hundredfoot,	1,597	123		
					Thirtyfoot,	1,765	19		
					Snee,	1,807	10		
					Boulder,	1,845	40		
					Third,				None.
					Fourth,				None.
					Fifth,			2,020	None.
125	B. D. Hutchinson,			1,136	Third,	1,950			
					Fourth, (?)	1,980			
					Fifth, (?)	2,090		2,090	
126	John F. Westboy,	1	Bellevue Gas Co.,	811	Hundredfoot,	1,374	93		Water (salt).
					Thirtyfoot,	1,537	35		
					Third,	1,620	55		
					Fourth,	1,700	23		Gas at 1,713.
					Stray,	1,730	11		
					Fifth,	1,765	17	1,815	Oil at 1,770.
127	A. Bahl,	4	South Penn. Oil Co.,	1,150	Hundredfoot,				Salt water.
					Fourth,	2,054	34		Oil at 2,071.
					Fifth,	2,118	22		Gas at 2,125.
128	Taylor,	1	Philadelphia Co.,	1,092		*			Gas.
129	J. M. Crawford,	1	Philadelphia Co.,	829		*			Oil and gas.
130	Stewart Crawford,	1		826		*			Oil and gas.
131	John Crawford,	2	South Penn. Oil Co.,	834		*			Oil and gas.
132	Andrew Bahl,	3	South Penn. Oil Co.,	1,086		*			Oil.
133	Wm. Jackman,	2	Appalachian Oil Co.,	1,147		*			Oil.
134	Wm. Jackman,	1	Appalachian Oil Co.,	1,171		*			Oil.
135	Samuel Taylor,	1	Appalachian Oil Co.,	1,165		*			Oil.
136	Samuel Taylor,	1	Manufacturers L. & H. Co.,	1,170					
137	Jane Crawford,	1	Manufacturers L. & H. Co.,	958		*			
138	J. W. Cook,	1	J. W. Cook,	949		*			Gas.
139	J. W. Cook,	(?)2	J. W. Cook,	(?)829		*			Gas.
140	Leonard Delp,	2	South Penn Oil Co.,	(?)851					Oil.
141	Samuel Taylor,	1	South Penn. Oil Co.,	(?)895					Oil.

ROSS TOWNSHIP, ALLEGHENY COUNTY.

142	Joseph Quail,	1	Manufacturers L. & H. Co.,	950	Hundredfoot,	1,543	53		
					Thirtyfoot,	1,686	29		
					Boulder,	1,725	80		
					Third,				Bottom 1,847.
					Fourth,	1,867	35		
					Fifth,	1,932	13		

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*No record.

ROSS TOWNSHIP, ALLLEGHENY COUNTY.—Continued.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
143	J. M. Allen,	1	E. J. Baldwin,	1,087	Hundredfoot,	1,710	97		Oil. 1st pay 1,710; 2nd pay 1,721.
					Thirtyfoot,		70		Gas at 1,851; oil at 1,893.
					Boulder,		35		
					Third,		40		
					Fourth,		41		
					Fifth,		30	2,108	
144	Hahn Heirs,	1	E. J. Baldwin,	1,001	Hundredfoot,		105		First oil 1,629; 2nd 1,637.
					Thirtyfoot,		70		Gas at 1,805.
					Third,		40		
					Fourth,		36		
					Fifth,		28	2,142	
145	W. H. Crider,	1	American Nat. Gas Co.,	905					Coal 3 ft. 250; 2 ft. 240; 3 ft. 430.
					Salt (Butler),	1,310	142		Gas at 1,326 and 1,347.
					Hundredfoot,	1,485	107		Water at 1,515; gas 1,525; water 1,530.
					Thirtyfoot,	1,642	38		
					Snee,	1,705	21		
					Boulder,	1,728	40		
					Third and 4th,	1,798	35		
					Fifth,	1,866	12		
146	McCutcheon,	1	American Nat. Gas Co.,	962	Hundredfoot,	1,530	(?)20		
					Thirtyfoot, (?)	1,678	50		
					Snee, (?)	1,740	40		Gas at 1,590.
					Boulder,	1,783	9		Gas at 1,792-1,795.
147	Mrs. Margaret Mec-Knight.	1	American Nat. Gas Co.,	968	Hundredfoot,	1,533	102		
					Thirtyfoot,	1,695	45		
					Snee,	1,760	25		
					Third,	1,850	15		
					Fourth,	1,865	25		
					Fifth,	1,925	10		

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*No record.

148	J. R. Sangree,	1	American Nat. Gas Co.,	1,075	Hundredfoot,	1,680	115		
					Thirtyfoot,	1,840	50		
					Snee,	1,890			
					Boulder,	1,925	25		Gas at 1,925.
					Third,	1,990	35		With 8-ft. break. Gas 2,005 ft. below break.
					Fourth,	2,050	30		
149	Hammerschmitt,	1	Tewilliger & Co.,	908	Hundredfoot,	1,740			Pay 15 ft. at 1,517.
150	Hammerschmitt,	2	Tewilliger & Co.,	932	Hundredfoot,	1,510	10		1st pay little oil & gas 1,543. 2nd pay 1,535; 3rd pay 1,573 (3 ft.).
151	Joseph Grow,	(?)1		893					Oil. (?)
152				1,129					Oil.
153				1,142					Oil.
154				1,055					Oil.
155	Cooper Heirs,	(?)1	Bellevue Gas Co.,	975		*			Gas.
156	Pete Farley,	1		907		*			Said to have made oil.
157	Payton,	1		972		*			
158				968					
159	D. B. Bassett,	1	Bellevue Gas Co.,	1,148		*			
160	Henry Wilt,	1	Philadelphia Co.,	1,105		*			
161	Heim,	(?)		976		*			
162				963					
163	John Link,		Philadelphia Co.,			*			
164	Real,	1	Philadelphia Co.,			*			
165	F. Heim,	1	Frank Neeley,			*			
166	F. Heim,	2	Frank Neeley,			*			
167	Thos. Hartman,	1	Wm. Stier,	1,027		*			Oil.
168	South Penn Oil Co.,	1	South Penn. Oil Co.,			*			Dry hole.

McCANDLESS TOWNSHIP, ALLEGHENY COUNTY.

169	B. S. Redpath,	1	South Penn. Oil Co.,	952	Third,	1,818	14		Oil at 1,824.
170	John Stoop,		South Penn. Oil Co.,	967	Third,	1,838	14		Oil at 1,839.
171	N. Brant,	3	South Penn. Oil Co.,	1,170		*			
172	N. Brant,	4	South Penn Oil Co.,	1,184	Third,	2,040	25	2,065	Oil at 2,042-2,052.
					Hundredfoot,	1,712	144		Sand close and inferior. No oil. or water.
173	N. Brant,	5	South Penn. Oil Co.,	1,175	Third,	2,036	25		1st pay 2 ft. 2,038; no water. 2nd pay 3 ft. 2,049.
174	Sandle Heirs,	3	South Penn. Oil Co.,	1,195	Hundredfoot,	1,727	138		Sand, inferior. No oil; little water.
					Third,	2,050	26		Oil 2,052-2,062.
175	Sandle Heirs,	4	South Penn. Oil Co.,	1,182	Hundredfoot,	1,720	140		Sand inferior; no oil; but little water.
					Third,	2,037	20		Sand inferior; no oil or water.
					Fourth,	2,118	15	2,133	Gas at 2,118; oil at 2,120.

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*No record.

McCANDLESS TOWNSHIP, ALLEGHENY COUNTY.— Continued.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
176	W. R. Perner,	1	W. R. Perner,	1,144	Hundredfoot,	1,687	10		Marks probably streak.
					Third,	2,002		2,024	Not through sand; oil in 3rd sand.
177	Good & Noble,	(?)1	South Penn. Oil Co.,	1,205	Third,	2,069	9		Oil at 2,070; no water.
178	Kuhlbers (50 A),	1	South Penn. Oil Co.,	1,061	Third,	1,918	10		Oil in Third.
180	Austin Heirs,	1	C. H. Shermer,	1,044		*			Oil in Third.
181	Austin Heirs,	3	C. H. Shermer,	1,033		*			Oil in Third.
182	Haslett,	2	C. H. Shermer,	1,112		*			
183	Haslett,	1	C. H. Shermer,	1,131		*			
184	Henry Keilu,	1		1,091					
185	John Dear,	1	South Penn. Oil Co.,	1,088	Third,	1,938	31	1,971	Oil; 1st pay 1,941; 3 ft.; 2nd pay 1,954; 3 ft. No water.
186	C. H. Kretzer,	1	Chas. H. Kretzer,	1,131	Third,	1,975	29	2,004	Oil: 1st pay 1,982; 2nd pay 1,990.
187	M. Schwaub,	1		1,135	Third,	1,979		2,003	1st pay 1,982.
188	M. A. Lawson,		South Penn. Oil Co.,	1,108	Third,	1,919		1,963	Oil in Third.
189	J. M. Moon,		South Penn. Oil Co.,	1,022	Hundredfoot,	1,458	111		Non-productive.
					Third,	1,770	31		Oil at 1,772.
190	Wm. Krammer,	1	South Penn. Oil Co.,	976		*			
191	Joseph Riechard,	1	Shenango Oil Co.,	973				1,890	Gas.
193	Adam Kyle,	1	United Gas Co., (?)	1,053		*			
194	Philip Sarver,	3	South Penn. Oil Co.,	1,008	Hundredfoot,	1,533	104		Poor; no oil or gas.
					Third,	1,865	10		Gas at 1,866; very light.
					Fourth,	1,925	5		
195	Philip Sarver,	1	South Penn Oil Co.,	1,015		*			Gas.
196	Wm. Toogood,	1	Philadelphia Gas Co.,	1,099	Hundredfoot,	1,602			Gas.
					Thirtyfoot,	1,780			Gas.
					Third,	1,948			Gas.
					Fourth,	1,994			Gas.
					Fifth,	2,047		2,322	Gas.
197	Wm. McKinley,	1	South Penn. Oil Co.,	1,210		*			Oil in 3rd; gas in 4th.

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*No record.

198	E. Greasler,	1	South Penn. Oil Co.,	1,204	Hundredfoot,	1,701	111		Unproductive.
					Thirtyfoot,	1,865	32		Unproductive.
					Snee,	1,926	22		Unproductive.
					Boulder,	1,970	6		Unproductive.
					Third,	2,000			Light shells.
					Fourth,	2,071	19		Gas at 1,078.
199	Wm. McKinney,	1	South Penn. Oil Co.,	1,088	Butler,	1,380	130		Salt water 1,440.
					Hundredfoot,	1,590	110		
					Snee,	1,816	25		
					Boulder,	1,865	5		
					Third,	1,904	20		Oil at 1,917.
200	Charles Pierce,	1	Bridgewater Gas Co.,	982		*			Gas.
201	Pierce,	2		1,094	Hundredfoot,	1,592	101		Salt water.
					Thirtyfoot,	1,753	24		
					Boulder,	1,777	27		
					Third,	1,911	13		
					Fourth,	1,967	18		Gas in Fourth.

FRANKLIN TOWNSHIP, ALLEGHENY COUNTY.

204	William English,	2	South Penn. Oil Co.,		Hundredfoot,	1,530	150		Pay 1,570-1,585; oil.
					Thirtyfoot,	1,718	13		
					Third,	1,857	20		
					Fourth,	1,922	11	1,936	
205	T. D. Richie,	1	Philadelphia Gas Co.,	1,031					Some gas.
206	Robert C. Wright,	1	Philadelphia Gas Co.,	1,226	Hundredfoot,	1,755	104		
					Third, (?)	2,070	30		Gas.
					Fourth, (?)	3,135	12		Gas.
207	Robert C. Wright,	(?)1	Forest Oil Co.,		Fourth, (?)	1,736	10	1,756	
208	Wattenpool,	1	C. Woodling,	1,070					Confidential record.
209	Chas. W. Morrow,	2	South Penn. Oil Co.,	1,183	Hundredfoot,	1,694			Oil.
210	Wallace,	2	John McCarthey,		Hundredfoot,	1,745		1,806	Oil; 1st pay 1,765; 2nd pay 1,780; 3rd 1,799.
211	Hague,	1	John McCarthey,	1,263	Hundredfoot,	1,760		1,814	Oil; 1st pay 1,790; 2nd pay 1808.
212	Skiles Heirs,	4		1,177	Hundredfoot,	1,665		1,742	Oil; 1st pay 1,684; 2nd pay 1,723.
213	George Brant,	1	John McCarthey,	1,218	Hundredfoot,	1,702		1,778	Oil and gas at 1,720.
214	J. Shearing,	3		1,260	Hundredfoot,	1,761	99		Oil at 1,792.
215	J. Shearing,	2		1,296	Hundredfoot,	1,804	60		Pay 1,806 20 ft. thick.
216	J. Shearing,	1		1,238	Hundredfoot,	1,742		1,799	Pay 1,744-1775.
217	Eduard McColough,	1	Philadelphia Co.,	1,125		*			A little oil in Hundredfoot.
218	Skiles Heirs,	2			Hundredfoot,	1,624		1,667	Gas in top of sand. Pay oil and water 1,637.

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*No record.

FRANKLIN TOWNSHIP, ALLEGHENY COUNTY.—Continued.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
219	Wm. Neeley,	1	South Penn. Oil Co.,	1,171	Hundredfoot,	1,633	106		Gas 1,640; oil 1,682.
					Snee,	1,845	12		
					Boulder,	1,885	13		
					Fourth,	1,964	10		
220	J. D. Prophater,	1	Columbia Oil Co.,	1,046		*			
221	George Smith,			1,009		*			Little oil in Hundredfoot.
					Hundredfoot,	1,470	95		Gas; no oil but salt water at 1,515.
222	George Smith,	1	South Penn. Oil Co.,	997	Thirtyfoot,	1,655	10		No oil; water.
					Snee,	1,690	5		No oil; water.
					Third,				None.
223	J. E. Berger,		South Penn. Oil Co.,	904	Hundredfoot,	1,380	90		No oil or water.
					Thirtyfoot,	1,535	7		Oil at 1,536; no water.
224	John Swint,	1	McCalmont Oil Co.,	1,004		*			Oil in Boulder sand.
225	John Swint,	3	McCalmont Oil Co.,			*			
226	Swint,	2	McCalmont Oil Co.,	1,046	Snee,	1,723	15	1,774	Oil.
227	Swint,	4	McCalmont Oil Co.,	993	Hundredfoot,				No oil or water.
					Snee,	1,675	14		Oil.
228									
229	Winterberger,	6	George E. McGill,	862	Boulder,	1,579	5		Gas; no water.
230	G. W. Cope,	2		889	Snee,	1,542	10		Oil.
231	John Rhodes,	4	South Penn. Oil Co.,	915	Thirtyfoot,	1,527	15		Little oil.
					Snee,	1,565	5		
					Hundredfoot,	1,342			
232	Mrs. C. M. Smith,	1or9		921	Thirtyfoot,	1,516	10		
					Snee,	1,559			
					Boulder,				Gas.
233	Mrs. C. M. Smith,	2	Dutihl Oil Co.,	932	Thirtyfoot,	1,535			
234	Leather,	3		1,099					Oil.
235	Leather,	5		1,070					Oil.

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*No record.

237	J. H. Piffer,	1	South Penn. Oil Co.,			*			
238	D. V. Pegher,	1	South Penn. Oil Co.,	1,105	Hundredfoot,	1,574	124		**Gas and water and oil at 1,616.**
239	Lynn Vandevort,	1	South Penn. Oil Co.,	1,250	Third (probably),	*			

PINE TOWNSHIP, ALLEGHENY COUNTY.

					Hundredfoot,	1,503			No oil, gas or water.
241	McClintock Heirs,	2	American Natural Gas Co.,	1,068	Thirtyfoot,	1,606	40		No oil, gas or water.
					Boulder,	1,726			Good sand, little gas.
					Fourth,	1,890	8		Gas at top.
242	Christ. Byer,	1	Southern Oil Co.,	1,122		*			Unproductive.
243	S. H. Herron,	1	South Penn. Oil Co.,	1,258	Hundredfoot,	1,730		1,802	Not through sand. Oil 1,765-1,785.
244	Harry Fogal,	1	South Penn. Oil Co.,	1,300		1,775		1,839	Oil 1,802-1,820.
245	W. J. Reynolds,	2	South Penn. Oil Co.,	1,251		*			Oil.
246	W. J. Reynolds,	4	South Penn. Oil Co.,	1,221		*			Oil.
247	Wm. Reynolds,	1		1,034		*			Gas. (?)
248	Wm. McKindley,	3		993		*			
249	Wm. Dall,	1	Bridgewater Gas Co.,	1,219		*			Good gasser.
					Hundredfoot,	1,747	103		Sand, close.. Little water. No oil or gas.
250	F. M. Finley,	4	South Penn. Oil Co.,	1,259	Third,				None.
					Fourth,	2,076	14	2,090	Gas; no oil.
					Hundredfoot,	1,731	101		No oil or gas; little water.
251	F. M. Finley,	3	South Penn. Oil Co.,	1,234	Third,	2,050	5		Shelly.
					Fourth,	2,103	5		Gas at 2,107.
					Fifth,			2,173	None.
252	George Raulshouse,	1		1,045		*			Unproductive. Also B. M. 184.
					Hundredfoot,	1,555	105		Sand, close. No oil, gas or water.
253	John Logan,	1	South Penn. Oil Co.,	1,098	Third,	1,880	4		Show of oil.
					Fourth,	1,915	10		Gas at 1,915; 350 pounds rock pressure.
					Hundredfoot,	1,710	90		
					Thirtyfoot,	1,864			
253	F. Brant,	1	American Natural Gas Co.,	1,279	Snee,	1,924			
					Boulder,	1,966			
					Third,				No good.
					Fourth,	2,077			Gas at 2,085.
					Hundredfoot,	1,644	106		Little water; no oil or gas.
254	Samuel Campbell,	1	South Penn. Oil Co.,	1,200	Third,				None.
					Fourth,	2,022	8		Gas at 2,026. Rock pressure 500 pounds.

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*No record.

PINE TOWNSHIP, ALLEGHENY COUNTY.—Continued.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
255	Henry Fogal,	2	South Penn. Oil Co.,	1,094	Hundredfoot,	1,556	114		Light show of oil. Some water.
					Third,				Light shells.
					Fourth,	1,905	5		Gas at 1,906.
256	Andrew English,	1	South Penn. Oil Co.,	1,091	Hundredfoot,	1,548	77		Show of oil.
257	Joe English,	1	South Penn. Oil Co.,	1,124	Hundredfoot,	1,574		1,626	Oil and water at 1,606-1,610.
									Oil and water at 1,613-1,615.
									Oil and water at 1,623-1,626.
					Hundredfoot,	1,665	90		No oil or water.
					Thirtyfoot,	1,855	20		No oil or water.
					Snee,	1,895	10		No oil or water.
258	John Gangler,	1	South Penn. Oil Co.,	1,234	Boulder,	1,935	5		No oil or water.
					Third,				None.
					Fourth,	2,075	5		No oil or water. Very light gasser.
259	Samuel McCash,	1	Colestock & Norton,	1,150		*			Said to have had a small show of gas.
260	Alexander Lurting,	1	Philadelphia Co.,	1,120		*			Gas.
					Hundredfoot,	1,585			
					Thirtyfoot,				Slate and shells.
261	Alexander Lurting,	1	American Natural Gas Co.,	(?)1,159	Snee,	1,790			
					Boulder broken,				
					Third,				None.
					Fourth,	1,939	10		Gas at 1,939.
262	A. T. Zimmerman,	1		1,185		*			Gas.
263	Porter,	1	M. Finnegan,	1,220	Hundredfoot,	1,605	101		Coal at 600.
					Hundredfoot,	1,266	105		
264	Robert Kennedy,	3	South Penn. Oil Co.,	1,266	Snee,	1,910	10		
					Third,	1,990	12		Oil; no water.
265	J. C. Martin,			1,229	Hundredfoot,	1,608			
					Third,			2,160	Gas well.

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*No record.

266	List or Irwin,	1	M. Finnegan,	1,146	Hundredfoot,	1,520			Salt water: 1,440-1,558.
					Third,	1,834	4		Show of gas.
					Hundredfoot,	1,595	100		Break, 1,610-1,620. Pay 1,614-1,649. 2nd pay 1,670-1,675; water in sand.
267	Kennedy,	4		1,237					
					Snee,	1,819	10		Oil.
268	Dean,	1		1,149	Snee,	1,728	11		Oil.
					Hundredfoot,	1,581			Pay 1,647-1,654; pay 1,676-1,684; oil and water.
269	James U. Dean,	4							
					Snee,	1,805	11	1,816	Pay 1,808-1814.
					Hundredfoot,	1,492	135		Pay 1,552-1557; water 1,580 little oil.
270	J. C. McDonald,	2	McDonald Bros.,	1,157	Snee,	1,726	15		
					Boulder,	1,774	6		
					Third,	1,821	8	1,909	
					Hundredfoot,	1,575	98½		1st pay 1,628-1638; 2nd pay 1,663-1,673.
271	J. S. Marshall,	2	Planet Oil Co.,	1,223	Snee,	1,797	23		Pay 1,797-1,800; oil.
					Boulder,	1,854	7		Oil.
272	J. S. Marshall,	(?)1	Planet Oil Co.,	1,255	Hundredfoot,	1,600	100		1st pay 1,625-1,640; 2nd pay 1,650-1,665; 3rd pay 1,685-1,700.
273	C. Wilheim,	2	South Penn. Oil Co.,	1,156	Hundredfoot,	1,486	14	1,631	1st pay 1,489-1,493; 2nd 1,564-1,566.

MARSHALL TOWNSHIP, ALLEGHENY COUNTY.

274	Shernot,	1	Plank Road Oil Co.,	1,108	Hundredfoot,	1,564	106		Water and oil 1,624-1,633.
					Boulder,	1,820	13		
275	Sarver,	1	Plank Road Oil Co.,	1,133	Hundredfoot,	1,582			Oil 1,592 and 1,627.
					Hundredfoot,	1,538	117		Oil at 1,621.
					Snee,	1,748	7		
276	Shernot,	2	Plank Road Oil Co.,	1,122	Boulder,	1,792			
					Third,	1,834			Shells.
					Fourth,	1,895		1,925	
277	Bradford Heirs,	2	M. Henshaw,	1,104	Hundredfoot,	1,524	99		
					Thirtyfoot,	1,693	31		
					Hundredfoot,	1,512	100		
278	Devine,	1	Lidecher & Stage,	1,088	Thirtyfoot,	1,694	12		
					Boulder,	1,798	3		
279	Dear Heirs,	1	Lidecher & Stage,	1,103		*			

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*No record.

MARSHALL TOWNSHIP, ALLEGHENY COUNTY.—Continued.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands. Name.	Depth.	Thickness.	Total depth of well.	Remarks.
280	Dulihl or C. Smith,	6		958	Hundredfoot,	1,375	105		No good.
					Thirtyfoot,	1,534	11		Oil.
					Boulder or Snee,	1,584	10		Oil.
					Sand,	2,185	90		
					Sand,	2,500	12		
					Sand,	2,585	25		
					Sand,	2,700	12	2,712	
281	G. G. Goff,	1		989		*			
282				1,122					
283	C. Pfaff,	3		890	Hundredfoot.	1,325	102		Gas 1,414-1,419.
					Snee,	1,535	15		Oil in top.
284	C. Pfaff,	1		886	Hundredfoot,	1,322	98		
					Snee,	1,525	16		Oil.
285	J. A. Montgomery,	1	J. A. Montgomery,	(?)1,084	Hundredfot,	1,505	110		Salt water.
					Boulder,	1,763		1,785	Gas with some oil.
286	E. Headland,	1	Shilds & Williams,	1,123		*			Unproductive.
287	G. I. Sickles (60A),	8	South Penn. Oil Co.,	1,091	Hundredfoot,	1,495			Oil 1,498-1,512.
288	G. I. Sickles,	7	South Penn. Oil Co.,	1,083	Hundredfoot,	1,487			Oil 1,490-1,512.
289	G. I. Sickles,	10	South Penn. Oil Co.,	1,104	Hundredfoot,	1,504			Oil 1,506-1,527.
290	Amos Mashey,	3	Chartiers Oil Co.,	1,269	Hundredfoot,	1,646			Oil at 1,648.
291	Amos Mashey,		Chartiers Oil Co.,	1,134		*			Oil.
292				1,138					
293				1,214					
294				1,217					
295	Robinson Heirs,	9	Southern Oil Co.,	1,074	Hundredfoot,	1,447	53	1,517	Oil; 1st pay 1,447—20 ft.; 2nd pay 1,488; 12 ft.
296	Robinson Heirs,	11	Southern Oil Co.,	1,069	Hundredfoot,	1,428	69	1,507	Oil; 1st pay 1,428—17 ft.; 2nd pay 1,471; 10 ft.
297	Wm. Fowler,	6	Wm. Fowler,	1,061	Hundredfoot,	1,413			Oil.
298	Wm. Lloyd,	4	South Penn. Oil Co.,	1,080	Hundredfoot,	1,430		1,519	Oil; pay 1,487—8 ft.

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*No record.

299	W. & J. Warren,	1	South Penn. Oil Co.,	1,078	Hundredfoot,	1,435		1,522	Oil; 1st pay 1,432—12 ft.; 2nd pay 1,487—5 ft.; 3rd pay 1,495—14 ft.
300	John Warren,	3	South Penn. Oil Co.,	1,099	Hundredfoot,	*			
					Snee,	1,688	10		Oil; no water.
301	William Fowler,	(?)10		1,218		*			
302	William Fowler,	(?)8		1,211		*			
303	William Fowler,	5	South Penn. Oil Co.,	1,109		*			
304	William Fowler,	11	South Penn. Oil Co.,	1,201		*			
305	M. Steigerwald,	1	South Penn. Oil Co.,	1,268	Hundredfoot,	1,685	97		Oil 1,745-1,760.
306	J. B. Smith,	3	South Penn. Oil Co.,	1,252	Hundredfoot,	1,575	100		Oil; 1st pay 1,580—15 ft.; 2nd pay 1,630—13 ft.
307	J. B. Smith,		South Penn. Oil Co.,	1,238	Hundredfoot,	1,560	101		Oil; 1st pay 1,564—2 ft.; 2nd pay 1,576—12 ft.; 3rd pay 1,616—8 ft.
308	J. B. Smith,	11	South Penn. Oil Co.,	1,139	Hundredfoot,	1,451	114		Oil at 1,457.
309	J. B. Smith,	9	South Penn. Oil Co.,	1,178	Hundredfoot,	1,490		1,574	Oil; 1st pay 1,498—8 ft.; 2nd 1,543—5 ft.
310	L. Duthett,	(?)1	South Penn. Oil Co.,	1,079	Hundredfoot,	1,402	115		Oil at 1,438.
311	L. Duthett,	(?)2	South Penn. Oil Co.,	(?)1,088	Hundredfoot,	1,405	125		Oil at 1,442.
312	Thomas Crea,	1	South Penn. Oil Co.,	1,156	Hundredfoot,	1,516	94		Sand close and inferior; no oil, gas or water.
					Snee,	1,732	5		Poor sand.
					Boulder,	1,764	9		Poor sand.
					Third,				Light shells; no Fourth or Fifth sands.
313	Thomas Crea,	1		1,128		*			
314	Nicholas Stroble,	1		1,216		*			
315	Phillip Frey,	1	South Penn. Oil Co.,	1,132	Hundredfoot,	1,520	85		Close and inferior; no oil or gas.
					Thirtyfoot,	1,670	20		Poor sand.
					Snee,	1,710	8	2,006	Poor sand. Light shells for Third, Fourth and Fifth.
316	S. E. Bridenstein,	1	Parker & Edwards,	1,130		*			Oil.
317	E. Allman,	1	C. P. Caughey & Co.,	1,110	Hundredfoot,	1,537		1,559	Pay to 1,557; oil.
318	James Neeley,	2	C. P. Caughey & Co.,	1,128	Hundredfoot,	1,562		1,585	Pay 1,562-1,582; oil.
319	S. E. or H. Bridenstein.	2		971		*			
320	D. Gilliford,	1		1,072					

HOPEWELL TOWNSHIP, BEAVER COUNTY.

323	E. E. Laughner,	1	E. E. Laughner,	1,751	Hundredfoot,	1,305		1,343	Oil.
324	Wm. C. Kelley,	1	E. E. Laughner,	775	Hundredfoot,	1,314		1,348	Unproductive.
325	Gailey & Richie Lot,	1	Gailey and Richie,	(?)805	Hundredfoot,	1,240		1,256	Gas.
326	C. S. McDonald,	2			Hundredfoot,				Gas.

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*No record.

HARMONY TOWNSHIP, BEAVER COUNTY.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
328	Economy Property,	4	South Penn. Oil Co.,	932	Hundredfoot,	1,470			Oil 1,473.
329	Economy Property,	5	Eachel & Richie,	899	Hundredfoot,	1,435		1,457	Oil 1,537-1,546.
330	Economy Property,	10	South Penn. Oil Co.,	1.041	Hundredfoot,	1,581			Oil 1,534.
331	Economy Property.	12	South Penn. Oil Co.,	990	Hundredfoot,	1,524		1,557	Oil 1,531.
332	Economy Property,	14	South Penn. Oil Co.,	893	Hundredfoot,	1,423		1,442	Oil 1,425-1,432.
333	Economy Property,	22		1,132		*			Oil.
334	Economy Property,	23		1,108		*			Oil.
335	Economy Property,			850		*			Unproductive.
336	Economy Property,	61	P. M. Shannon,	868	Hundredfoot,	1,379	20	1,407	Oil for 10 ft in.
337	Economy Property,	19	P. M. Shannon,	1,056	Hundredfoot,	1,576	24	1,612	Oil 1,576 to 1,596.
338	Economy Property,	55	P. M. Shannon.	803	Hundredfoot,	1,322	23	1,350	Oil 1,338-1,345.
339	Economy Property,	53	P. M. Shannon,	788	Hundredfoot,	1,308	20	1,338	Oil 1,320-1,328.
340	Economy Property,	49	P. M. Shannon,	744	Hundredfoot,	1,269		1,289	Gas 1,281.
341	Economy Property.	41	P. M. Shannon,	790	Hundredfoot,	1,295	23	1,326	Oil and gas 1,308-1,316.
342	Economy Property,	39	P. M. Shannon,	773	Hundredfoot,	1,275	22	1,309	Oil 1,285-1,295, and gas.
343	Economy Property,	34	P. M. Shannon,	789	Hundredfoot,	1,270	23	1,305	Gas and oil 1,280-1,290.
344	Economy Property,	45	P. M. Shannon,	780	Hundredfoot,	1,283		1,312	Oil and gas 1,296-1,306.
345	Economy Property,	36	P. M. Shannon,	765	Hundredfoot,	1,261	23	1,296	Oil and gas 1,274-1,282.
346	Old Legionville Well,		P. M. Shannon,	706	Hundredfoot.	1,196			Oil and gas.
347	Economy Property,	22	P. M. Shannon,	773	Hundredfoot,	1,265	28	1,642	Hard and dry.
348				829					
349	Economy Property,	13	South Penn. Oil Co.,	943	Hundredfoot,	1,476	21	1,497	Oil and gas to 3 ft. in and 1,479-1,485.

*No record.

ECONOMY TOWNSHIP, BEAVER COUNTY.

351	Hugh Moore,	(?)1	The Fort Pitt Gas Co.,	(?)748	Hundredfoot, Fourth,	1,300 1,606	25 6		Gas.
352	B. D. Moore,	1	South Penn. Oil Co., (?)	757		*			
353	B. D. Moore.	2	South Penn. Oil Co.,	890		*			
354	Jacob S. Scheirer,		Chas. Fowler,			*			Gas in Fourth.
355	J. H. Davis,	7	R. W. Miller & Co.,	868	Hundredfoot, Thirtyfoot, Snee, Boulder,	1,362 1,500 1,560 1,601	65 10 15 9		Oil and gas (flowing).
356	A. M. Davis,	1	R. W. Miller & Co.,	779	Hundredfoot,	1,305			Oil.
357	Margaret Walter,	3		954		*			Oil.
358	J. W. Ludwig,	1	South Penn. Oil Co.,	1,018	Hundredfoot,	1,521	20		Oil.
359	M. Walter,	1	South Penn. Oil Co.,	901	Hundredfoot,	1,416			Oil.
360	Eli Horning,	1	Gailey Bros.,	1,016		*			Unproductive.
361	Joseph Craig,	3	Zartman, Miller & Co.,	818		*			
362	Joseph Craig,	2	Zartman, Miller & Co.,	856	Boulder,	1,590		1,598	Oil and gas.
363	Joseph Craig,	1	Zartman, Miller & Co.,	883	Boulder,	1,605		1,615	Oil and gas.
364	Joseph Craig,	(?)1	Zartman, Miller & Co.,	971		*			Oil.
365	James Heirs,	2	Ann Oil Co.,	853		*			Unproductive.
366	A. Lentz,	1		1,049		*			Unproductive.
367	N. & A. Northeim,	1		845	Hundredfoot,	1,350			Little show of oil; no water.
368	J. R. Brown,	3	George Reed,	(?)1,120	Hundredfoot,	1,535	38		Oil 1,566-1,573.
369	Ehrman,	2		995	Hundredfoot,	1,465	33		Oil 1,487-1,495.
370	Robert Charleston,	1	George S. Reed,	(?)1,111	Hundredfoot,	1,510		1,543	
371	Fruith Heirs,	(?)1	C. P. Caughy & Co.,	950	Hundredfoot, Snee,	1,434 1,640	 8	 1,739	
372	Anna Hartling,	(?)1		1,008		*			Unproductive.
373	Fred Moore,	2	Neeley & Co.,	1,126	Hundredfoot.	1,589		1,603	Oil.
374	Fred Moore,	(?)1	Neeley & Co.,	1,142	Hundredfoot,	1,617			Oil: break at 1,634-36.
375	Bock Heirs,	4	Sommerville & Caughey.	1,151	Hundredfoot,	1,619		1,628	Oil.
376				1,080					
377	Fred Swain,	1			Hundredfoot.	1,516	57		No oil.
378	William Moore,	1		951		*			Unproductive.
379	George Bryant,	2	Baden Gas Co.,	805	Hundredfoot,	(?)1,288			Some gas.
380	John Galliger,	1		945		*			
381	Ehrman,	2		883		*			
382	John Grazier,	2	George Reed,	(?)765	Hundredfoot,	1,160	27		Gas. Coal at 102—2 ft. Hard shell 1,325—2 ft. Red rock 1,820—25 ft. Hard sandstone 1,905—20 ft.
383	C. F. Straube,	2	C. F. Straube & Co.,	868	Hundredfoot,	1,263	42		Oil. Pay 1,301-1,305.
384	Wm. Blackham,	1	Henry Stler.	1,183	Hundredfoot,	1,631	32		Unproductive.
385	Wilson Neeley,	1	Neeley Harbison & Co.,	1,034		*			
386	Norton Brown,	1	South Penn. Oil Co.,	1,092	Hundredfoot,	1,532	49	1,597	Unproductive.
387	Hammerle,	1		1,052	Hundredfoot,	1,467		1,501	About 8 ft. of pay; Oil.
388	Hammerle,	2		(?)1,114	Hundredfoot,	1,457		1,493	Oil; 7 ft. pay 1,483.

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*No record.

ECONOMY TOWNSHIP, BEAVER COUNTY.—Continued.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
389	Hammerle,	5		1,094	Hundredfoot,	1,517	34	1,557	Oil; 1st pay top 1,517—8 ft. 2nd pay top 1,537—6 ft. 3rd pay top 1,150—3 ft.
390	Hammerle,	3		1,095	Hundredfoot,	1,517		1,558	Oil; top pay 1,517—37 ft.
					Hundredfoot,	1,370	80		Show of oil 1,420; "Very nice looking sand."
391	Wm. Gross,	2	Manufacturers L. & H. Co.,	934	Thirtyfoot (shells).	1,485	25		
					Snee,	1,565	10		
					Boulder (white sand).	1,594	6		Gas 1,595; 3 ft. coal 1,415.
392	Horst Heirs,	1	Manufacturers L. & H. Co.,	961	Hundredfoot,	1,393	55		Some oil 1,415.
					Boulder,	1,615	16	1,650	Gas at 1,617 and 1,622.
393	Henry Emrich,			1,036		*			
394	Bradford Heirs,	8	South Penn. Oil Co.,	1,040	Hundredfoot,	1,440		1,461	Oil.
395	Bradford Heirs,	7	South Penn. Oil Co.,	1,044	Hundredfoot,	1,449		1,464	Oil.
396	Bradford Heirs,	6	South Penn. Oil Co.,	1,072	Hundredfoot,	1,465		1,490	Oil.
397	Bradford Heirs,	(?)1		1,116		*			Unproductive.
398	Thomas Bradford,	(?)1	South Penn. Oil Co.,	1,061	Hundredfoot,	1,420		1,300	
399	Thomas Bradford,	(?)1		1,076	Hundredfoot,	1,436	57	1,505	Oil at 1,482.
400	Wm. Emrich,	1	Appalachian Oil Co.,	1,082	Hundredfoot,	1,500		1,546	Oil 1,521-1,531.
401	Wm. Emrich,	3	Appalachian Oil Co.,	1,067	Hundredfoot,	1,482		1,530	Oil 1,504-1,515.
402				1,062					
403	Bock Heirs,	13	South Penn. Oil Co.,	1,076	Hundredfoot,	1,455		1,504	Oil 1,480 and 1,495.
404	Aaron Stwart,	3	Shocheeker & Lamberton,	1,108	Hundredfoot,	1,472	72		Oil.
405	Aaron Stewart,	1	Shochecker & Lamberton,	1,116	Hundredfoot,	1,475	70		Oil (good pay).
406	Aaron Stewart,	4	Shochecker & Lamberton,	1,116	Hundredfoot,	1,478	7		Oil (good pay).
407	Aaron Stewart,	6	Shochecker & Lamberton,	1,066	Hundredfoot,	1,441	61		Oil.
408	Bradford Heirs,	1	Hazlewood Oil Co.,	1,065	Hundredfoot,	1,445	70		Oil 1,465.
					Third (?)	1,760	5		
					Fourth,	1,800	2		

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*No record.

409	Bock Heirs,	19	South Penn. Oil Co.,	1,076	Hundredfoot,	1,435		1,507	Oil 1,440 and 1,483.
410	Concord Church,	1	South Penn. Oil Co.,	1,210	Hundredfoot,			1,606	Oil at 1,575.
411	Aaron Stewart,	2	South Penn. Oil Co.,	1,226	Hundredfoot,	1,590		1,659	Oil.
412	Aaron Stewart,	1	South Penn. Oil Co.,	1,218	Hundredfoot,	1,578		1,640	Oil.
413	Thomas Whipple,	4	E. H. Jennings,	1,232	Hundredfoot,	1,587		1,610	Oil and gas 1,590.
414	Mary Reed,	14	Unity Oil Co.,	1,107	Hundredfoot,			1,501	Pay 1,467-1,487.
415	Robert Wallace,	7	Campbell, Miller & Co.,	1,113	Hundredfoot,	1,470		1,526	Oil 1,475 and 1,487.
416	Robert Wallace,	9	Campbell, Miller & Co.,	1,110	Hundredfoot,	1,468	67	1,547	Oil 1,475 and 1,486.
417	Reed Heirs or Steve White.	1	South Penn. Oil Co., (?)	1,117		*			
418	Aaron Wilson,	1	Barrett & Logan,	1,071	Hundredfoot,	1,447		1,491	Unproductive. "No white sand."
419	James Hendrickson,	1	A. J. Lloyd,	1,036		*			Unproductive.
420	Jacob Hendrickson,	1	John Snyder & Sons,	963		*			Unproductive.
421	Chaney Heirs,	1	Barrett & Logan,	935	Salt or Butler, Hundredfoot,	1,073 1,265	92 45	1,533	Gas and water at 1,090. "Broken and gray." Nothing but shale and a few shells below the 100-foot.

NEW SEWICKLEY TOWNSHIP, BEAVER COUNTY.

424	Mrs. Harvey,	1	John Snyder & Sons,	935	Hundredfoot,	1,224	18	1,267	Unproductive.
425	John Ruchert,	1	Frank Neeley,	993		*			Unproductive.
426	Linenbrink,	1		730		*			Unproductive.
427	George Frietch, (?)	1		874		*			Unproductive.
428	Elias Mengle,	2	John Snyder & Sons,	1,089		*			Unproductive. (?)
429	John Yeager,	1	John Snyder & Sons,	988		*			Only a show of Hundredfoot.
430	J. C. McCauley,	1	C. L. Norton & Co.,	1,211	Hundredfoot,	1,380	80		Unproductive.
431	C. J. Bonzo,	1	Frank Neeley,	1,145		*			Unproductive.
432	Dave Lowrey,	1	John Snyder & Sons,	995	Hundredfoot,	1,226	62		Unproductive.
433	Mrs. Dean,	1	John Snyder & Sons,	953		*			Unproductive.
434	Dan Black,	1	John Snyder & Sons,	1,089	Hundredfoot,	1,340	60		Some oil.
435	Dan Black,	1	Joe Adams,	1,060		*			Flowed oil.
436	George Bonzo,	1	John Snyder & Sons,	1,169	Butler gas,	1,231	81		Gas.
437	John White,	2	John Snyder & Sons,	1,159	Hundredfoot,	1,532	39		Unproductive.
438	John Snyder,	2	John Snyder & Sons,	994	Hundredfoot, Third, (?)	1,176 1,430	50 12		Unproductive. Unproductive; shale to 2,550.
439	Samuel Burns.	1	Rochester Glass Co.,	940		*			Unproductive.
440	Harrison Bonzo,	1	South Penn. Oil Co.,	1,008	Hundredfoot,	1,172	28		White sand 1,176; pay sand 1,200; said to be small gas well.
441	John Bonzo,	1	John Snyder & Sons,	970		*			
442	Zeno Geohring,	2	South Penn. Oil Co.,	1,243	Hundredfoot,	1,407		1,496	White sand 1,432-1,486; oil 1,470.
443	Cookson, (?)	(?)	Bridgewater Gas Co., (?)	1,010	Hundredfoot, (?)	1,193	(?)78		Small oil well. See platted section, Pl. IV, p. 37.
444	H. W. Brenner,		South Penn. Oil Co.,	1,027		*			
445	L. D. Brenner,	3	South Penn. Oil Co.,	990		*			

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*No record.

NEW SEWICKLEY TOWNSHIP, BEAVER COUNTY.—Continued.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
446	J. T. Fezel,	1	A. McCormick,	1,015	Hundredfoot,			1,198	Oil.
447	L. H. Geohring,	1	John Snyder & Sons,	1,129	Hundredfoot,	1,329	52	1,381	Oil at 1,356.
448	Mary (or Jas) Haskins,	1	John Snyder & Sons,	1,075		*			
449	Henry Douglas,	1	John Snyder & Sons,	967	Hundredfoot,	1,237		1,255	
450	William Metz,	2		1,160		*			
451	George Kline,	2		1,172		*			
452	George Kline,	1	John Snyder & Sons,	1,161	Hundredfoot,	1,390		1,440	Oil in top of sand.
453	George Kline,	2	John Snyder & Sons,	1,137		(?)1,362		1,367	Little oil.
454	John Fresheorn,	1	W. A. Geohring,	1,111		*			Unproductive.
455	Carl Miller,,	1		1,054		*			
456	Henry Stang,	1	New Castle Gas Co.,	1,154		*			
457	John Herzog,	1		1,263		*			
458	Joel Powell,	1	John Snyder & Sons,	1,040		*			
459	C. R. Bonzo,	2	Manufacturers L. & H. Co.,	1,161	Butler gas,	1,340	14		
					Hundredfoot,	1,431	10	1,441	
460	C. R. Bonzo, (?)	(?)1	Manufacturers L. & H. Co.,	1,123	Hundredfoot, (?)	(?)1,408		1,423	Gas.
461	Westley Filbert,	(?)1	John Snyder & Sons,	1,027		*			Gas.
462	Wm. Fezel,	2	Rochester Tumbler Co.,	1,092		*			Unproductive.
463	Goettman,	1	Barrett & Logan,	939		*			Unproductive.
464	Chris Geohring,	1	John Snyder & Sons,	1,130	Hundredfoot,	1,424	76		Oil in top of sand.
465	Wm. Phillips,	2	John Snyder & Sons,	1,166	Hundredfoot,	1,472		1,504	
466	Margaret Peirsol,	1	John Snyder & Sons,	1,144	Hundredfoot,	1,453		1,502	Oil in top of sand.
467	Baker Heirs,	2	John Snyder & Sons,	1,137	Hundredfoot,	1,440	25	1,465	Oil in top of sand.
468	Frank Metz,	1	John Snyder & Sons,	1,086	Hundredfoot,	1,393		1,426	Oil in top of sand.
469	Eliza Baker,	1	John Snyder & Sons,	1,073	Hundredfoot,	1,380		1,402	Oil in top of sand.
470	John Blank,	1	John Snyder & Sons,		Hundredfoot,	1,290		1,314	Oil in top of sand.
471	J. J. McElhaney,	5	Appalachian Oil Co.,	940	Hundredfoot,	*			Made over 100 bbls. per day.
472	Albert Kemmer,	7	John Snyder & Sons,	960	Hundredfoot,	*			Made about 6 bbls. per day.
473	Albert Kemmer,	10	Unity Oil Co.,	930	Hundredfoot,	1,267		1,293	Oil.
474	Albert Kemmer,	1	Unity Oil Co.,	923	Hundredfoot,	1,261		1,290	Oil.
475	Blank & Boehn,	2	Unity Oil Co.,	913	Hundredfoot,	1,256		1,286	Oil.

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*No record.

476	Blank & Boehn,	1	Unity Oil Co.,	915	Hundredfoot,	1,246	46	1,292	Oil at 1,260.
477	Graham Dunlap,	8	Mfrs. L. & H. Co.,	1,131	Hundredfoot,	1,276	64		Gas.
478	Chris Wagner,	1	Mfrs. L. & H. Co.,	1,081	Hundredfoot,	1,418		1,453	Oil.
479	Steel,	1	Rochester Glass Co.,	1,120		*			
480	McElhaney,	2	South Penn Oil Co., (?)	1,079	Hundredfoot,	1,362	15		Unproductive.
481	John Eisenbran,	1	John Snyder & Sons,	993	Hundredfoot,	1,310		1,340	Gas and water in top of sand.
482	Wm. Wright,	1	E. Dambaugh,	1,109	Hundredfoot,	1,405	86	1,491	Unproductive.
483	Edgar Wright,	1	McGrain, (?)	1,104		*			Unproductive.
484	George Eisenbrown,	1	Mfrs. L. & H. Co.,	992	Hundredfoot,	1,312		1,395	Gas in top of sand; little oil at 1,362.
485	George Schultz,	1	John Snyder & Sons,	989	Hundredfoot,	1,316	83		Unproductive.
486	Fred Kirschler,	1	John Snyder & Sons,	1,101	Hundredfoot,	1,440		1,513	Unproductive.
487	Wm. Phillips,	2	Mfrs. L. & H. Co.,	1,146	Hundredfoot,	1,400	60	1,550	Gas in top of sand.
488	Simon Phillips,	1	Mfrs. L. & H. Co.,	1,101	Hundredfoot,	1,412		1,476	Gas in top of sand.

CRANBERRY AND JACKSON TOWNSHIPS, BUTLER COUNTY.

490	J. N. Wright,	1	Logan & McKann,	1,124		*			Unproductive.
491	Otto Heirs,	1		1,133		*			Unproductive.
492	Thos. Donley,	1	W. A. Geohring,	1,087		*			Unproductive; said to have had a good show of oil.
493	Chas. Dombaugh,	1	Lenyon & Linton,	1,049	Hundredfoot,	1,408			5 ft. oil in sand.
494	Gailhaugh,	2	Adams and Stauffer,	1,042		*			
495	Chas. Dombaugh,	1	J. M. Patterson,	1,120		*			Unproductive.
496	Geo. Keck,	1	South Penn. Oil Co.,	1,026	Hundredfoot, Thirtyfoot, Snee,	1,292 1,440 1,530	108 35 5		No oil, gas or water. No oil, gas or water. No oil, gas or water; no Third or Fourth sands found.
497	Cleaver Heirs,	1	Daniel Isman (?)	984		*			
498	Cleaver Heirs,	2	Samuel Schaffer. (?)	1,026		*			Oil in Hundredfoot.
499	John Deemer,	1	John Snyder & Sons, (?)	1,019		*			
500	C. H. Rape,	2		1,027		*			
501	John Rape,	1		1,061		*			
502	Henry Zehner,	1	Wm. Russell,	1,123		*			
503	Newton Garvin,	20	Assoc. Prod. Oil Co.,	1,194	Hundredfoot,	1,403		1,489	Oil; coal at 150, 440 and 520. "Break" 1,462-71; oil 1,481.
504	B. W. Garvin,	9	Assoc. Prod. Oil Co.,	1,333	Hundredfoot, Snee, Boulder, Third,	1,425 1,691 1,734 1,709			
505	B. W. Garvin,	14	Assoc. Prod. Oil Co.,	1,262	Hundredfoot,	1,469	135	1,623	Oil 1,540.
506	B. W. Garvin,	23	Assoc. Prod. Oil Co.,	1,193	Hundredfoot,	1,422		1,512	Oil 1,476.
507				1,167					
508	W. H. Vandevort,	1	Assoc. Prod. Oil Co.,	1,146	Hundredfoot,	1,363	92		Oil 1,417.
509	Frederick Meeder,	5	South Penn. Oil Co.,	1,118	Hundredfoot,	1,344	88		Oil 1,402.
510	Frederick Meeder,	9	South Penn. Oil Co.,	1,189	Hundredfoot,	1,416	95	1,479	Oil 1,445 and 1,472.

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*No record.

CRANBERRY AND JACKSON TOWNSHIPS, BUTLER COUNTY.—Continued.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
511	Frederick Meeder,	1	South Penn. Oil Co.,	1,173	Hundredfoot,	1,400	109	1,490	Oil 1,461 and 1,485.
512	G. W. Gardner,	2	Assoc. Prod. Oil Co.,	1,089	Hundredfoot,	1,306		1,414	Oil 1,383.
513	J. Dumbaugh,	2	Assoc. Prod. Oil Co.,	1,073		*			Some oil and gas.
514	J. Dumbaugh,	1	Assoc. Prod. Oil Co.,	1,060		*			Some oil and gas.
515	Wm. Garvin,	1	Bears and McKee,	1,047		*			
516	J. Rowan,	2	Hazlewood Oil Co.,	1,135	Hundredfoot,	1,420	130		Oil 1,471.
					Snee,	1,648	11	1,659	Oil 1,648.
517	J. Rowan,	1	Hazlewood Oil Co.,	1,139	Hundredfoot,	1,428	136		Oil 1,465.
					Snee,	1,645	11	1,656	Oil 1,648.
518	Cathrine Rice,	1	South Penn. Oil Co.,	(?)1,075	Hundredfoot,	1,390	80		No oil or water.
					Snee,	1,587	14		Oil at 1,594.
					Boulder,	1,630	5		No oil or water.
519	Thos. Robinson,	3	Hazlewood Oil Co.,	1,087	Hundredfoot,	1,400			
					Snee,	1,603	13		Oil at 1,603.
520	Thos. Robinson,	4	Hazlewood Oil Co.,	1,077	Hundredfoot,	1,394			
					Snee,	1,596	9		Oil at 1,596.
521	Thos. Robinson,	1	South Penn. Oil Co.,	1,084	Hundredfoot,	1,400	75		No oil or water.
					Snee,	1,602	18		Oil at 1,608; no water.
522	Bertha Ulrich,	1	South Penn. Oil Co.,	(?)1,071	Hundredfoot,	1,390	95		No oil, gas or water.
					Snee,	1,606	8		Oil at 1,608.
523	Bertha Ulrich,	2	South Penn. Oil Co.,	1,071	Hundredfoot,	1,401	103		No oil or water.
					Snee,	1,604	5		No oil or water.
524	Dutihl Heirs,	5	South Penn. Oil Co.,	1,169	Hundredfoot,	1,479	83		Oil at 1,483 and 1,526.
525	L. A. Nesbit,	2	H. E. Bryner,	1,274	Hundredfoot,	1,586		1,627	Break 1,615; oil.
526	L. A. Nesbit,	1	H. E. Bryner,	1,202	Hundredfoot,	1,517		1,552	Oil 1,519.
527	B. Garvin,	3	H. E. Bryner,	1,208	Hundredfoot,	1,521		1,590	Oil and gas 1,532; break 1,546.
528	B. Garvin,	(?)	H. E. Bryner,	1,112		*			Some gas. (?)
529	Nesbit Heirs,	4		1,125		*			Oil.
530	Nesbit Heirs,	1		1,112		*			Oil.
531	Nesbit Heirs,	3		1,093		*			Oil.
532	Dr. E. Crawford,	3	Hoch Bros., (?)	1,219		*			Oil.

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*No record.

533	Dr. E. Crawford,	1		1,125		*			Oil.
534	J. Gordon,	3	Hope Bros., (?)	1,150	Boulder,	1,726			Gas.
535	J. A. Cookson,	2		1,125		*			Oil.
536	Duncan,	1	J. L. Peters,	1,107	Hundredfoot,	1,400	130		Salt water.
					Snee,	1,620	16	1,770	Oil.
537	Duncan,	2	J. L. Peters,	1,103	Hundredfoot,	1,405	130		Salt water.
					Snee,	1,615	16		
					Boulder,	1,672	12		Oil 1,672.
538	Boehm,	1	J. L. Peters,	1,088	Hundredfoot,	1,389	130		
					Snee,	1,590	16		
					Boulder,	1,647	14		Oil.
539	T. M. Marshall,	1	J. L. Peters,	1,086	Hundredfoot,	1,383	130		
					Snee,	1,592	16		Oil.
					Boulder,	1,649	12	1,680	
540	E. McKinny,	1	J. L. Peters,	1,094	Hundredfoot,	1,390	130		Gas.
					Snee,	1,590	16		Gas.
					Boulder,	1,645		1,775	Gas.
541	Joseph Geohring,	2	South Penn Oil Co.,	(?)1,048	Hundredfoot,	1,392	101		Oil 1,416 and 1,465.
					Hundredfoot,	1,472	141		Salt water 1,536; gas 1.582. and salt water 1,584.
542	D. Hendrickson,	1	Eisler & O'Brien,	1,189	Snee,	1,695	9		Show of oil in top.
					Boulder,	1,754	18		Some gas at top.
543	E. J. Cookson,	1	Pill & Quinine Oil Co.,	1,102	Hundredfoot,	1,433			Unproductive.
544	Alfred Cookson,	1		1,250		*			
545	Chris Heohn,	1		1,069		*			
546	John Geohring,	1		1,108		*			
547	Wm. Twentier, (?)	1		1,016		*			
548	Calvin Wirt,	(?)2	Ann Oil Co., (?)	(?)1,086		*			
549	A. J. West,	1	Eisler & O'Brien,	1,096	Hundredfoot,	1,357	89		Unproductive. (?)
550	Edward Little,	2		1,156		*			Unproductive.
551	G. W. & N. B. Knauff,	1	South Penn. Oil Co.,	1,099	Butler gas,			1,295	Some gas.
					Hundredfoot,	1,333	69		Some gas.
552	Sarah Ramsey,	1	South Penn. Oil Co.,	1,142	Butler gas,			1,374	
					Hundredfoot,	1,385	85		Oil. Coal 560.
553	B. R. Ramsey,	2	South Penn. Oil Co.,	1,165	Butler gas,			1,360	
					Hundredfoot,	1,399	88		Oil. Coal 540.
554	B. R. Ramsey,	1	South Penn. Oil Co.,	1,168	Butler,			1,360	
					Hundredfoot,	1,398	89		Oil. Coal 560.
555	Edwin Ramsey,	3	South Penn. Oil Co.,	1,141	Hundredfoot,	1,366	85		Oil.
556	W. H. Ramsey,	5	South Penn. Oil Co.,	1,166	Hundredfoot,	1,389	89		Oil.
557	Newton Garvin,	19	Assoc. Prod. Oil Co.,	1,232	Hundredfoot,	1,440		1,529	Oil in Hundredfoot.

*No record.

ADAMS AND FORWARD TOWNSHIPS, BUTLER COUNTY.

Map number.	Farm Name.	Number.	Company.	Elevation by spirit level.	Oil and Gas Sands.			Total depth of well.	Remarks.
					Name.	Depth.	Thickness.		
560	Sarah Cote,	1	W. H. Long,	1,159	Hundredfoot,	1,479		1,568	Oil at 1,525 and 1,550.
561	Nellie Campbell,	3	W. H. Long,	1,186	Hundredfoot,	1,499		1,589	Oil; 1st pay 1,552; 2nd 1,568; 3rd 1,579.
562	H. W. Miller,	1	Downie Pump Co.,	1,062	Hundredfoot, Thirtyfoot,	1,390 1,510	97 	 1,515	Gas at 1,515; coal at 180 and 510; limestone 290 ft.
563	Park Heirs,	1	Ann Oil Co.,	1,036		*			
564	John Balfour,	1	South Penn. Oil Co.,	1,124	Butler gas, Hundredfoot,	1,270 1,399	92 133	 1,770	Oil at 1,424 and 1,462.
565	John Balfour,	5	South Penn. Oil Co.,	1,264	Hundredfoot,	1,537	116	1,653	Oil at 1,547 and 1,622.
566	T. Anderson,	(?)	Elcho Oil Co.,	1,136		*			Oil.
567	T. Anderson,	(?)1	John C. Foy,	(?)1,144	Hundredfoot,	1,490	95	1,590	Oil at 1,520 and 1,560.
568	Wm. Davidson,	3	South Penn. Oil Co., (?)	1,041		*			Gas well.
569	Douthett Heirs,	(?)2	South Penn. Oil Co.,	1,077		*			Oil.
570	Douthett Heirs,	(?)1	South Penn. Oil Co., (?)	1,112		*			Oil.
571	Wm. (?) Theilman,	1	John C. Toy,	(?)1,033	Butler gas, Hundredfoot, Snee,	1,260 1,410 1,560	40 115 15	 1,620	Coal at 200 ft.
572	John Martin,	1	South Penn. Oil Co., (?)	1,005		*			Gas.
573	John Martin,	2	South Penn. Oil Co., (?)	1,011		*			Gas.
574	Douthett Heirs,	(?)1	South Penn. Oil Co., (?)	993		*			Gas.
575	E. Streeter,	(?)1	South Penn. Oil Co., (?)	985		*			
576				1,223					
577				1,184					Oil.
578				1,118					Oil.
579				1,004					Oil.
580	Kennedy Heirs,	5	South Penn. Oil Co.,	1,022	Hundredfoot,	1,308		1,385	Oil at 1,319 and 1,350.
581	Andrew Kennedy,	1	South Penn. Oil Co.,	1,062		*			Oil.
582	J. Gilkey,	10	South Penn. Oil Co.,	1,079	Hundredfoot,	1,345		1,446	Oil 1,372 and 1,417.
583	J. Gilkey,	9	South Penn. Oil Co.,	1,180	Hundredfoot,	1,452			Oil 1,546.
584	J. Gilkey,	7	South Penn. Oil Co.,	1,096	Hundredfoot,	1,368		1,452	Oil at 1,374 and 1,438.

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*No record.

585	Chas. File,	8	South Penn. Oil Co.,	1,109		*			Oil.
586	Wm. Kline,	1		1,031		*			Unproductive.
587	W. J. Blakely,	1		1,077		*			Unproductive.
588	C. H. Thieleman,	4	Evans City Gas Co.,	1,132		*			
589	Staple,	(?)1	Amer. Oil Dev. Co.,	1,144	Hundredfoot,	1,396			Oil at 1,426.
590	Lockwood,		South Penn. Oil Co.,	1,118		*			Gas.
591	Lockwood,		South Penn. Oil Co.,	1,126		*			Oil.
592	Lockwood,		South Penn. Oil Co.,	1,156		*			Oil.
593	Wm. McKinney,	(?)1	Massilon & Butler Oil Co.,	1,132					Oil.
594	Wm. McKinney,	(?)2	Massilon & Butler Oil Co.,	1,10[illegible]		*			
595	Wm. McKinney,	(?)3	Massilon & Butler Oil Co.,	1,154		*			Oil.
									Oil.
596	J. M. Eckstein,	1	J. M. Eckstein,	971	Hundredfoot,	1,224	127		Pay 1,254.
					Snee,	1,447	17		Gas 1,453.
					Third, (?)	1,540		1,554	Rock pressure of gas 950 lbs.
597	J. Cashdollar,	1	Eisler & O'Brien,	1,052	Hundredfoot,	1,300			Oil 1,368.
598	John Staples,	6	Eisler & O'Brien,	1,007	Hundredfoot,	1,250			Oil 1,310.
599	John Staples,	2	Adams & Labaugh,	1,005		*			Oil.
600	John Staples,		Adams & Labaugh,	1,005		*			
601	John Staples,		South Penn. Oil Co., (?)	1,076		*			
602	Kauffman Heirs,	3	J. W. Dobaugh,	1,054	Butler gas,	1,158	100		
					Hundredfoot,	1,294		1,400	Oil 1,367-1,386.
603	Kauffman Heirs,	2	J. W. Dobaugh,	1,041	Butler gas,	1,145	100		
					Hundredfoot,	1,280		1,378	Oil 1,348-1,366.
604	George Covert,	4	Eisler & O'Brien,	995	Hundredfoot,	1,247	105		Oil; 1st pay 1,313; 2nd 1,321; 3rd 1,338.
605				981		*			
606	Chas. Wagner,	1	South Penn. Oil Co.,	(?)1,073	Hundredfoot,	1,318	92		Oil.
607	Chas. Wagner,	2	South Penn. Oil Co.,	1,072	Hundredfoot,	1,247	88		Oil.
608				1,004		*			
609				974		*			
610				960		*			Abandoned.
611	John A. Clark,	2	Finlay A. McIntosh,	955	Butler gas,	1,058	102		
					Hundredfoot,	1,180			Oil 1,224 and 1,265.
612	John A. Clark,	1	Finlay A. McIntosh,	953	Butler gas,	1,050	100		
					Hundredfoot,	1,175		1,225	Oil; pay 1,215-1,225.
613	George Morberger,	1	Haynes & Atkins,	1,008		*			Oil.
614				1,174					
615	Miller Heirs,	1	Robert Irvine,	1,187		*			
616	Miller Heirs,		South Penn. Oil Co., (?)	1,140		*			Oil.

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*No record.

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LEGEND

RELIEF
(printed in brown)

Figures showing heights above mean sea level instrumentally determined

Contours showing height above sea, horizontal form, and steepness of slope of the surface

DRAINAGE
(printed in blue)

Streams

CULTURE
(printed in black)

Roads and buildings

Churches and school houses

Private or secondary roads

Railroads

Tunnels

Bridges

Ferries

Dams

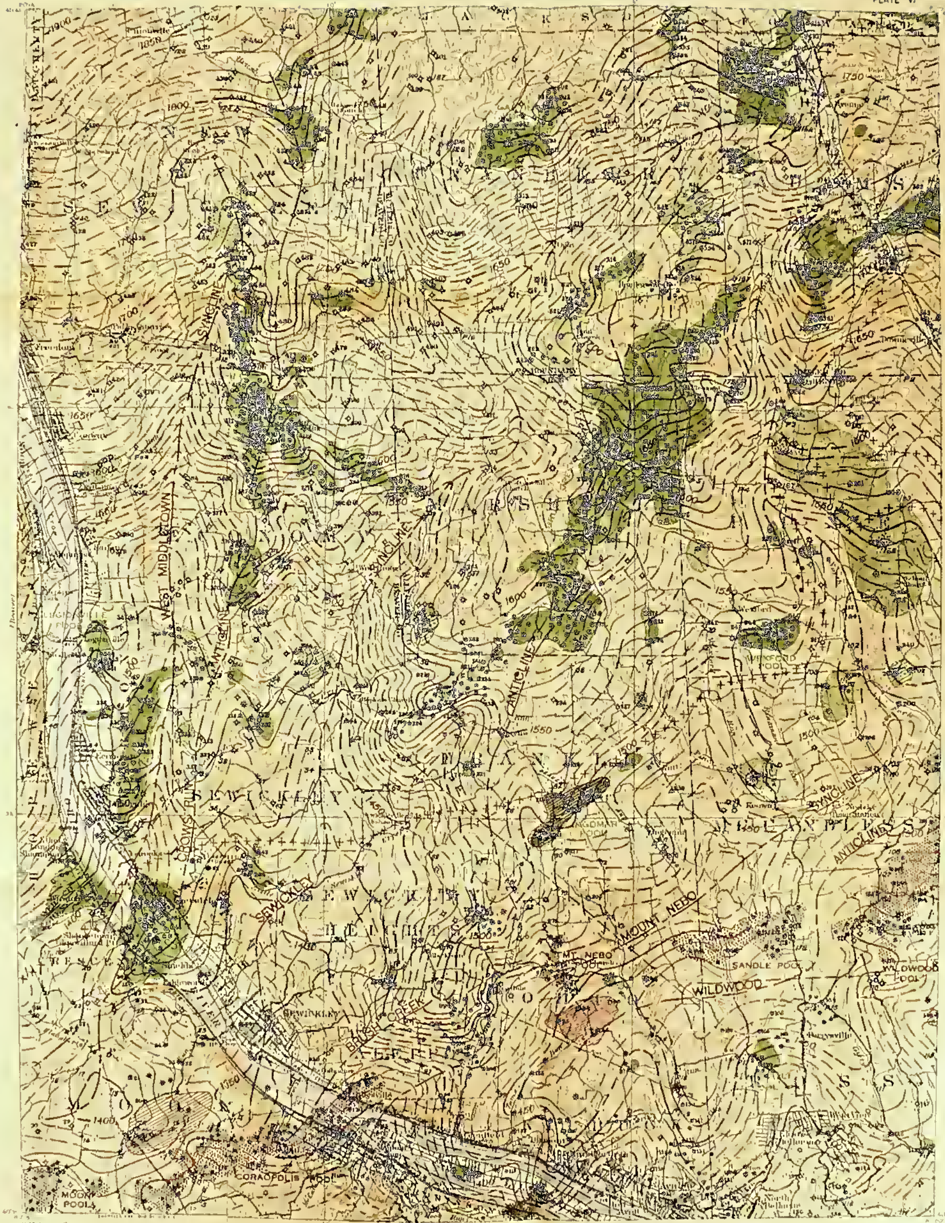
County lines

Township lines

City village and borough lines

Triangulation stations

Bench marks



LEGEND

Pools of oil or gas in Hundred-foot sand, getting salt water with the production

Gas pools in Hundred-foot sand showing no salt water

Known salt water areas in Hundred-foot sand, without oil or gas

Known dry areas in Hundred-foot sand, without oil or gas

Contours on top of Hundred-foot sand, interval 10 feet. Datum plane is 2000 feet below sea level. Numbers show height in feet above datum

Oil pools in Gordon sand

Gas pools in Gordon sand

Approximate northwest extent of the Third or Gordon sand

Bench marks

Note.—For description of these bench marks see corresponding numbers in appendix

Oil wells

Gas wells

Oil and gas wells

Show of oil

Show of gas

Dry holes

Holes about which nothing is recorded

Wells bearing numbers are mentioned in the text, either under the heading of Elevations and partial Records of Wells on the Sewickley quadrangle, or in the discussion of the oil and gas pools by townships

H M Wilson Geographer
[illegible]
Topography by [illegible]
Control by D H Baldwin and C A Ciunet
Surveyed in 1905-1906
Surveyed in cooperation with the State of Pennsylvania

MAP OF SEWICKLEY QUADRANGLE PA., SHOWING OIL AND GAS POOLS IN HUNDRED-FOOT AND GORDON SANDS, AND STRUCTURE CONTOURS ON TOP OF HUNDRED-FOOT SAND

Scale 1/62500

Contour interval 20 feet
Datum is mean sea level

Geology by M. J. Munn
under the direction of
Geo. H. Ashley

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